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Guide for Planning Investigations in the Ames 40- by 80-ft Wind Tunnel Operated by the Low Speed Wind Tunnel Investigations Branch (FHW)

(NASA-TM-101907) GUIDE FOR PLANNING INVESTIGATIONS IN THE AMES 40- BY 80-FT WIND TUNNEL OPERATED BY THE LOW SPEED WIND TUNNEL INVESTIGATIONS BRANCH (FHW) (NASA) 106 p

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INTRODUCTION

The National Full Scale Facilities Complex (40- by 80-Foot Wind Tunnel, 80- by 120-Foot Wind Tunnel, and Outdoor Aerodynamics Research Facility) are used primarily for research. When it is in the national interest, however, development testing can be done. Approval for such testing as military projects requires the request of the cognizant branch of the Department of Defense. The complex is staffed and operated by the National Aeronautics and Space Administration.

This guide provides information concerning use of the 40- by 80-Foot Wind Tunnel and specifies requirements for the design and fabrication of models that will be tested in this tunnel. The information contained in this manual is subject to change without notice due to the continual evolution of techniques and test equipment. It is essential that the staff of the Low Speed Wind Tunnel Investigations Branch (FHW) at Ames Research Center be consulted early during the planning of tests and the designing of models. In no case should model construction be started prior to such consultation.

Special devices, such as equipment for remote operation of model or aircraft engines and controls, are not enumerated in this guide. The Branch staff should be consulted concerning any special needs.

THE WIND TUNNEL

General

The wind tunnel has a closed 40- by 80-foot test section with semi-circular sides of 20-foot radius, and a closed-circuit air return passage. The general arrangement is shown in figure 1, and the test section and adjacent shop area are illustrated in figure 2. The test section is lined with sound absorptive material to permit acoustic research simultaneously while aerodynamic research is in progress. Figure 3 is a photograph of the test section with the acoustic lining installed.

The air is driven by six 40-foot-diameter fans powered by 40-pole, 6600 volt, three phase synchronous motors rated at 12 megawatts (18,000 horsepower) continuous with a two-hour 20% overload capacity. The motor-generator system which supplies power to the fan drive motors may be operated continuously at any power output up to a maximum of 106 megawatts.

Performance

Speed Range:	0 to about 300 knots, continuously variable
Pressure, Stagnation:	Atmospheric
Reynolds Number:	0 to about $3x10^6$ per foot with standard atmospheric conditions (see figure 4)
Temperature, Stagnation:	Uncontrolled. Dependent upon seasonal atmospheric variations; also, affected by operation of internal-combustion engines in models. Generally about 30° to 120°F. Figure 5 presents information which can be used to establish the wind tunnel temperature rise for a given engine. The upper curve is used to determine the actual temperature change based on running time.

Dimensions

Test Section:	39 feet high (with acoustic lining) 79 feet wide at horizontal center line (with acoustic lining) 80 feet long
Test-Section Doors:	40 feet wide by 49 feet long, one on each side of tunnel center line on top of tunnel. When open, a clear opening 78.5 feet by 49 feet is provided.

Hoist: A 35-ton and a 5-ton hoist mounted on a common bridge at the top of the test chamber are available to hoist models into the test section.

Elevators: Two elevators are available for transporting personnel and equipment from the street level to various stations in the test chamber.

The first elevator operates between street level to control/computer room, test section, and top of tunnel. Load capacity is 2500 pounds with a 6.5- by 7.0-foot area; doors are 6.5 feet wide and 7.0 feet high.

The second elevator operates between street level control/computer room, and the test section. Load capacity is 6000 pounds with a 10- by 10-foot area; doors are 9 feet 8 inches wide and 10 feet high.

Model Support

Primary Support System:

Type: The model support system consists of three movable struts mounted on a turntable. Two forward struts may be moved laterally to accomodate different model treads. A single telescoping tail strut may be adjusted longitudinally to accept models of varying tail length. Each strut is shielded from the air stream by a fairing which is mounted independent of the struts to a floor turntable; the struts are mounted on a strut turntable. The turntables are separately supported so as to eliminate fairing aerodynamic loads from model aerodynamic loads. Model angle-of-attack and angle-of-yaw are varied during testing by varying tail strut length or turning the turntable respectively. All support system functions are motorized and remotely operated.

As a safety feature, the balance frame is protected by a hydraulic snubbing system that is used to control balance frame movement thereby protecting the scale system during periods of large oscillatory loads such as those encountered during some rotor tests. The system is actuated by the tunnel operator and consists of a hydraulic pump, pressure sensing switch, eight single acting spring retracting hydraulic actuators plus the necessary plumbing and electrical controls to power the hardware. When restraint of the frame is desired, hydraulic fluid is passed through open solenoid check valves to the hydraulic actuators, which extend until they contact the balance frame. After contact is made, movement of the frame is increasingly restrained until regulated system pressure of 5000 psi is reached. A pressure sensing switch opens at 5000 psi activating the check valve feature of the solenoid check valve, causing a complete lockup of the balance frame. This entire operation takes less than 10 seconds to complete. Force and moment data from the scale system during this period are very inaccurate due to the forces applied to the frame by the snubbing system. A schematic diagram of the system is shown in figure 6.

Angle of Attack:

Range may be limited by any one of three conditions: namely (1) angular limitations of the ball sockets (see figure 7, (2) the maximum and minimum heights of the tail strut (further affected by tail length) (see figure 7, and (3) physical clearance within the test section for larger models. The strut ball and socket angular limits can be offset any amount up to ± 20° by insertion of wedges at the model attachment pads. Limits for any proposed arrangement can be determined from the information given in figure 7.

Angle of Yaw:

The turntable will rotate a total of 290° but the angle-of-yaw capability is determined by the initial orientation of the main struts. The yaw limits are shown in figure 7 for various positions of the main struts. The turntable center-of-rotation is located 7'6" behind the main-strut lateral travel path. The fairings on all three struts rotate in synchronization with the turntable so that they remain aligned with the wind stream throughout the 290° of travel. The angle-of-attack range remains as stated in the previous section regardless of yaw angle.

Allowable Strut Loads:

The tail strut is mounted in a gimbal and, hence, cannot transmit side, drag, and thrust loads. Various combinations of aerodynamic loadings (plus model dead weight) must be examined to estimate the resultant loads on the support struts. For example, model rolling moments are reacted by an incremental upload on one main strut and an equal download on the other; the resultant vertical load on a main strut will include components due to model weight, lift, pitching moment, and rolling moment. At some positions of yaw (main struts "right" and "left", figure 8) the model weight may exceed the roll scale capacity and will require a counter balancing weight.

Allowable loads per strut, lb.

Strut	Down	Up	Side	Drag	Thrust
Main (each)	35,000	15,000	4,000	8,000	8,000
Tail	18,000	18,000	-	-	-

Balance System Capabilities:

The transfer of strut loads to the scales through the balance frame system is illustrated schematically in figure 8. Mechanical lever systems transmit the lift tube, drag link, and side force link loads to seven scales with the following functions and capacities:

Scale	Total Range lb.	Unloaded, or "mid-dial" position, lb.	Function
Front lift	100,000	0	Left plus right front lift tube

Rear lift	100,000	0	Left plus right rear lift tube
Drag	40,000	0	Drag link
Front side force	20,000	0	Front side force link
Rear side force	20,000	0	Rear side force link
Front roll	40,000	0	Left minus right front lift tube
Rear roll	40,000	0	Left minus right rear lift tube

In addition to the direct scale forces shown in the table, are the following interactions: Moments due to drag forces acting above the drag restraint link are opposed by an equal opposing couple in the front and rear lift scales. Similarly, moments due to side forces are opposed by a couple in the roll scales.

Alternate Support Systems:

A variety of alternate support systems exist, and others can be fabricated for use on special tests. Where the primary system described above does not appear suitable, inquiries to the Low Speed Wind Tunnel Investigations Branch staff are invited.

Existing Alternate Systems:

1) Floor-mounted turntable for semispan models.
2) Various fixed-length struts for ground-effects tests.
3) Sting mount with high pressure air capability
4) Arrangements for parachute tests.

Operating Characteristics

The range of test conditions available with the primary model support system is presented in figure 9. Maximum allowable fan speed is 180 rpm, fan blade pitch travel is from -18 to 52 degrees, and maximum allowable power is 106 megawatts. The conditions shown apply without a model installed. Model blockage will increase the power required at any given tunnel speed.

The tunnel drive system is equipped with an emergency stop circuit. Examples of the rate of reduction of dynamic pressure for emergency stops from various tunnel speeds are shown in figure 10. The tunnel itself cannot be damaged by making an emergency stop from any condition; however, depending on the type of research testing being conducted, there is the possibility of doing significant damage to models, aircraft, and the tunnel. Specific procedures need to be outlined, briefed, and followed closely for these tests.

AUXILIARY FACILITIES

Shops and Offices

Final model assembly, instrumentation, and checkout is conducted in the Model Preparation Building adjacent to the 40- by 80-Foot Wind Tunnel. Approximately 9000 square feet of floor space is available for this purpose. All utilities available at the wind tunnel are available in the model preparation building. A 25 ton bridge crane is used for model handling in the Model Preparation Building.

Office space generally can be provided to meet the needs of contractors' representatives.

Utilities

The following utilities are available in the test chamber and shop areas:

Electric Power:

120 volt, 60 cycle, single phase
208 volt, 60 cycle, single and three phase
440 volt, 60 cycle, three phase

<u>Motor - Generator Set</u> - 15 KW 30 volt DC, 500 amps, shunt type DC generator 208/120 volt, 37.5 KVA, 3 phase, 104 amps, 400 hertz at full load.

26 volt, 15 amps, single phase, 400 hertz by use of a transformer.

24 to 30 volt DC, 7.5 KW portable unit.

<u>Jet engine electric starting</u>: Intermittent use 28-32 volt DC, 1500 amps normal with up to 1800 amps for 3 minutes.

<u>Variable frequency, three phase</u>. 0 to 150 cycles, 2120 KVA. Two sets are available. See figure 11 for the operating limits on each set.

0 to 400 cycles, 706 KVA. Two sets are available. See figure 12 for the operating limits on this equipment.

Arrangements for use of this variable frequency power must be made at least two months in advance.

Compressed Air:

High Pressure Air - 0 to 3000 psi at temperatures from ambient to 204°C (400°F). Flow rates are available to 40 pounds per second.

Shop Air - 125 psi, sufficient for hand tools.

Instrumentation Air - 125 psi, 50 cfm, dry air for instrumentation requirements.

Hydraulic Fluid:

32 gallons per minute maximum output at regulated pressures up to 3000 psi continuous, 5000 psi intermittent use.

Model Motors

Electric model motors ranging from 3 to 1500 horsepower and running on 150 cycle or 400 cycle variable frequency are available at Ames. Because of their heavy use, it is the users responsibility to check on the availability of the desired motors far in advance of the proposed test date.

Fuel Supply

JP-5 fuel can be supplied for the operation of turbojet or turbofan engines in the test section. The limits of flow rate are 50 gallons per minute at a pressure of 100 pounds per square inch. Suitable means are provided in the system for pressure and flow reduction. Arrangements for fuel requirements should be made at the earliest possible date.

Direct hook-up to the Ames fuel system is required. Use of on-board aircraft or model fuel tanks is not allowed. Purging of such tanks and pressurizing with an inert gas is required. Contact with the Low Speed Wind Tunnel Investigations Branch is required.

Model-Handling Equipment

A 10-ton and 6 1/2-ton hoist are available for handling large components for model assembly in the shop area prior to installation in the wind tunnel. The complete model is hoisted into the test section by the 35-ton hoist mentioned previously.

Rotor Test Apparatus

The performance of full scale rotor systems may be obtained by mounting them on the Rotor Test Apparatus (RTA). The RTA has the design flexibility to accommodate various rotor diameters and tip speeds. Figure 13 presents the power capability of the Rotor Test Apparatus for various combinations of tip speed, rotor diameter and transmissions.

The RTA is powered by two tandom mounted, variable speed electric motors, which can provide up to 3000 hp at either 437 or 268 output RPM. The RTA control systems provides collective, longitudinal and lateral control, with direct display of resolved blade flapping pitch angles. In addition, the experimenter can dynamically input step, ramp, sine wave, or random inputs to the primary control system over a frequency range of 0 to 30 Hz.

Tables 1 and 2 present the dynamic characteristics of the Rotor Test Apparatus on two main strut/tip combinations normally used with this module. The modes presented in the tables were identified by shake tests of the RTA in the wind tunnel. A force was applied at the rotor hub, in the longitudinal or lateral direction; the hub acceleration was measured in the same direction. The frequencies (w) of the principal modes were obtained from the transfer functions. In the tables, H is the peak response at the hub; C and M are the modal damping coefficient and modal mass as observed in the hub response. C_L is the modal damping coefficient for large amplitude motion; it should be used for ground resonance calculations. The frequency and amplitude of the mast modes depends on the hub inertia; the data given are for an H-34 hub and blade grips, without blades or equivalent blade mass. Normally, the 8 balance dampers are required for articulated rotors to avoid ground resonance. The balance locked data should be examined to assess the advisability of engaging the hydraulic snubber system.

Arrangements for the use of the RTA must be made far in advance of the actual test date because of heavy use of this equipment and complexity of the individual model build-up and test requirements.

INSTRUMENTATION

General

In order to ensure compatibility of instrumentation methods and equipment, it is essential that the FHW Branch staff be consulted early in the planning of test instrumentation. In no case should implementation of an instrument plan be started prior to such consultation.

Forms are available from the FHW for use as guidelines in the peparation of software and instrumentation and are included as Appendix A of this manual. The configuration form is needed as early as possible, but all forms are to be submitted no later than 6 months before a test date. A complete instrumentation book for the model must be prepared showing in detail the components instrumented, instruments used, circuit diagrams, and calibrations for the instruments. This instrumentation book shall arrive at the wind tunnel no later than the milestones identified in pretest discussions.

Data Acquisition

The 40- by 80- Data System is a distributed computer based data system which can be operated in an on-line mode or a stand alone with batch processing mode. It consists of the following major subsystems:

Kernal System
Static Force System
Control Console
Special Instrument System
Dynamic Recording System
Dynamic Analysis System
Transducer Conditioning System
High Speed Data Acquisition System
Display System
Closed Circuit Television System
Acoustic Recording System
Reference Pressure System

The data system block diagram is shown in Figure 14. The equipment is located in the control room and computer room on the second floor of the wind tunnel. In addition to this system, general purpose instrumentation is available for model setup, checkout, or for special test requirements.

The instrument subsystems in the control room are connected to the model via a general patch panel, permanently installed cables to junction boxes on the tunnel balance frame and from there to the model. Connectors identical to those in the junction boxes are located in the buildup area so that the same model cabling can be used during checkout and tunnel testing. This allows model checkout, system patch panel preparation, and system configuration setup prior to model entry to reduce hookup time in the wind tunnel.

The data system hierarchy uses three vertical levels of computer. The Realtime Executive Processor (REP) is used on-line to reduce data collected at data points to be used in the conductance of the test. The Data Gathering Processor (DGP) controls data acquisition, records data, computes data in real time and displays the computed data for model/tunnel parameter control. The Kernal System provides for signal conditioning, digitizing, multiplex/demultiplex and control of other hardware. These computers are connected via DEC DMC-11 communication hardware.

REP:

The REP is configured as follows:

VAX 11/780 CPU
1 Megabyte Semiconductor Memory
2 each, 9 track, 800 or 1600 bits per inch magnetic tape unit
2 each, 176 Megabyte RP06 disk
1 each, DEC WRITER terminal
2 each, line printer
Multiple VT-100 alphanumeric terminals

DGP: The DGP is configured as follows:

PDP 11/70 CPU
256 Kiloword core memory
2 each, 9 track, 800 or 1600 bpi magnetic tape unit
1 each, 44 Megaword RP04 disk
1 each, DEC WRITER terminal
1 each, card reader
1 each, line printer
1 each, VT-29 real time display driver
2 each, VT-100 alphanumeric terminals

KERNEL:

The Kernal consists of Preamplifier Filter Units (PAF), airborne and rackmount remote multiplexer/demultiplexer units (ABRMDU and RMRMDU), parallel resistance units (RCAL) and RMDU Control Units (RCU). The system is capable of having up to eleven PAF's connected to up to each of eight RMDU's connected to up to each of two RCU's; however, we do not have enough PAF's and RMDU's in our inventory to exercise the full capability of the systems. The diagram of the Kernel which follows shows two possible applications of general usage RMDU connection.

The ABRMDU can be mounted on a model, on the floating frame, in the control room or other appropriate location. It has the capability of accepting analog and digital signals, providing transducer excitation, bridge balancing and calibrate resistor insertion. The ABRMDU amplifies, digitizes, encodes and transmits data to the RCU in the form of a serial bit stream. The AB RMDU has eleven card slots which may be filled with a combination of the following types of cards:

Analog Multiplex	(AMX)	32 Channels
Digital Multiplex	(DMX)	3 x 12 Words
Excitation Bridge Control	(EBC)	8 Channels
Pre-Sample Filter	(PSF)	4 Channels
Follow and Hold Amplifier	(FH)	4 Channels

There also exist Pre-amplifier Filter boxes (PAF) which have twelve card slots in which EBC and PSF cards may be placed. Therefore, each PAF box can condition 32 channels of analog data. The RMRMDU's are mounted in the digitizer, control and computer rooms. They have either 8 I/O or 16 I/O card capability for the following types of cards:

Buffered Analog Multiplex	(BAMX)	32 Channels
Presample Filter	(PPSF)	8 Channels
Supervised Parallel Output	(SPO)	
Supervised Parallel Input	(SPI)	
Unsupervised Parallel Output	(UPO)	
Unsupervised Parallel Input	(UPI)	

The RCU demultiplexes the serial bit stream and routes data to any combination of the following output ports:

Data Gathering Processor	(DGP)
DAC 8 Bit Resolution	16 Channels
DAC 12 Bit Resolution	32 Channels
Serial Bit Stream (PCM Recording)	2 Channels
PDP 11/05 Minicomputer	

The RMDU and associated transducers may be checked prior to tunnel entry by using a Portable Address Generator (PAG). This allows for the calibration and checkout of all data channels in a model preparation area using the exact instrumentation and cabling which is to be used in the wind tunnel test.

Static Force System:

This system consists of:

Balances
Digitizers
Computer Interface

A "Floating Frame" system of beam balances is used to measure all six components of forces and moments on the complete model. A schematic representation of the general arrangement is shown in Figure 8. It should be noted that the floating frame is electrically insulated from the surrounding tunnel structure. Mechanical fouling between the floating frame and other structure is detected by checking for electrical continuity. Electrical power for model instrumentation may be grounded to the floating frame by using isolation transformers and special outlets in the control room. All instrumentation wiring then must be insulated from tunnel structure and from the model to the control room.

The Static Force System is used to record and monitor the basic 6-component aerodynamic force and moment data. These data are normally obtained from the scale beam-balance system. Output data are digitized and recorded in the DGP.

When the Static Force System is used to record scale beam-balance data, it has the sensitivities shown in Table 3.

Several sets of 2-component and 3-component load cells are available with normal force capacities from 800 to 15,000 pounds, and axial-force capacities from 800 to 12,000 pounds. These balances were designed to measure model loads in the X-Z plane, but may be utilized for varied special purposes.

Control Console:

The operation of the data acquisition system is centered at the control console. The following functions are incorporated in this console:

Display System
DGP Terminal
CRT Display
Function Key Pad
Run and Data Point Number
Scanivalve Position Control and Display
Scale Displays
Movie/Still Camera Control
Video Tape Recorder Remote Control

Special Instrumentation System:

The special instrumentation system consists of the following:

Computing Counters (6)
Digital Panel Meters (10)
Inclinometer
Yaw Readout
Barometer
Calibration Pressure (2)

With the present system, only seven of these special instruments can be operable at any one time.

Seven of the above instruments can be interfaced to the DGP. The special instruments have the following characteristics:

Computing Counter:

Model Number Anadex 1600R
Frequency Range 2 Hz to 20 Hz
Input Sensitivity From 10mv to 150v rms
Periods Averaged 1, 10, 100, or 1000
Input Impedance 20 KΩ
Normalizing Factor 5 Digits

Digital Panel Meters:

Model Number Newport Labs 2000A
Voltage Ranges 400mv, 4v, 40v, 400v
Resolution 4 3/4 Digits (1 Part in ±39999)
Input Impedance 1000 MΩ
Accuracy ±.01% Reading ±μv
Common Mode Rejection 120 dB
Normal Mode Rejection at 60 Hz, 60 dB

Inclinometer:

Range ±30°
Resolution 4 1/2 digits
Accuracy ±.01%

Yaw Readout:

Range 0 to 360°
Resolution .01°
Accuracy ±.05°

Barometer:

Reads in psia
Resolution 4 1/2 digits
Accuracy ±.15% of reading

Dynamic Recording System:

This system provides for the recording of 56 channels of analog data, one channel of time code, two channels of PCM data, two channels of timing data and one channel of miscellaneous data on a 14 track, one inch magnetic tape. The analog channels are frequency division multiplexed with seven channels per track. These signals are conditioned by the amplifiers in the high speed data acquisition system which provide anti-aliasing filters. An eighth channel on each of the eight FM tracks is common and is used for a time synchronizing signal. There are four groups of seven demodulators which can be patched to any track and whose outputs are cabled to the system patch panel. An additional group of eight demodulators, called quick-look, are patched to a Vu Data Bank of seven, two channel monitor scopes. By using this bank of demodulators, any multipliex group may be observed during recording. The system has a servo gun calibrator which allows for semi-automatic calibration to reduce setup and checkout time. An IRIG A/B time code generator (Datatron 3030-126), is included in the system to provide a master time of data clock/time code for the entire data acquisition system. The recorder is an Ampex FR 1900 which has direct and PCM (Miller code) electronics for the above use and 14 FM electronic plug-ins for one data signal per track.

Some System Specifications Are:

Intragroup Time Correlation	<30 μ sec
Harmonic Distortion	<.75%
Non-Linearity	<±.15%
Crosstalk and N/S	-40 dB
Input Voltage	±10v
Output Voltage	±10v
Input Single Ended, Isolated Output Current	50 ma
Band Width (3 dB)	1000 Hz
System Usable Band Width	300 Hz

Dynamic Analysis System:

This system is used in a stand alone mode for both data acquisition/analysis for test conductance. It consists of a 32 channel analog conditioning element (ACE) which can be sampled at rates up to 200 KHz. The primary use of the system is to select two of these 32 channels and perform one or more of the following analyses:

Fourier Transform
Inverse Fourier Transform
Auto Power Spectrum
Cross Power Spectrum
Auto Correlation
Cross Correlation
Histogram
Impulse Response
Transfer Function
Coherence Function
Characteristic Function
Analog Sampling
Averaging (1 to 524 K Linear or Exponential)
Hanning
Programming Capability

Two of the channels have 8 pole Butterworth anti-aliasing filters with band width from 10 Hz to 50 KHz. Anti-aliasing for the other channels is supplied by the amplifiers in the HSDAS. The controller is a PDP 11/45 with operator interface via a panel, or graphics display (Tektronix 4010). The system has two RK05 disks which allows RT11 software with FORTRAN callable modules for the above noted analysis algorithms. Display of the analysis is on a 4" by 5" CRT and/or graphics display. Data and signal outputs may be through any of the following:

Magnetic Tape (TU10)
Paper Tape Reader/Punch (PC11)
Frequency Synthesizer (Rockland 5100)
Graphics Terminal (Tektronix 4010) and Hard Copy Unit

There also is a pseudo random noise generator (HP 3722A) for use as a signal source. Some characteristics of the system analog input are:

Impedance 1MΩ
AC or DC Coupling
Range ±.125v to ±10v
Frame Size 64 to 8192 Samples

Transducer Conditioning System:

This system supplies excitation (DC), bridge completion, bridge balancing, shunt resistor calibration (Rcal) and external excitation. The characteristics of the system are as follows:

Model Moxon 2545
Excitation Range 0-20v and 20-40v
Rcal 4 Position Switch 50KΩ, 75KΩ, 125KΩ, 250KΩ, or 100KΩ, 150KΩ, 200KΩ, 500KΩ
Balance ±10mv for 10v Excitation
Eight Wire Capability

The transducers are connected to this system through the system patch panel. Normally, internal sense is used for the power supplies; however, the remote sense capability exists.

High Speed Data Acquisition System:

This system consists of sixty Newport 70A-4 amplifiers, Xerox Data Systems (XDS) sample and hold amplifier per channel, XDS 64 channel multiplexer and XDS ±14 bit analog to digital converter. This system is interfaced to the computer and unlike the other system, cannot operate in a stand alone mode. The characteristics of the system are as follows:

Input:
Guarded, Differential and Isolated
Impedance 300MΩ
Range ±10v
Gain 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000
Common Mode Rejection 120dB
Bandwidth 100 KHz
Accuracy .05% Full Scale

Output:
#1 Filtered, Connected to XDS Equipment Only
#2 Unfiltered ±10v, 100 ma, .1Ω
#3 Filtered,
4 Pole Bessel Low Pass 3 dB Point 1, 10, 30, 100, 300, 1K, 10K, 100 KHz

System:
Sample Rate, Max, 60K Sample/Sec (Disc Limitation)
100K Sample/Sec (XDS Limition)

Display System:

This system is used for real time display to assist in test conductance. Inputs are typically through the HSDAS amplifiers. It consists of the following:

Oscilloscope:

Tektronix 5A26 Amplifier & 5223 Oscilloscope
Input Impedance 1MΩ
Bandwidth DC to 1 MHz
Range 1v to 10v
Commonmode Rejection 300:1
Differential Isolated Inputs

Sweep Speed 20ns/div
Chop Rate 300 KHz ± 25%
Accuracy ±1%
8 channel

Visicorder (2 Each):

Honeywell 1858
18 Channels
Chart Speed 1, 2, 4, 8, 16 in/sec
Multiplier .1, 1, 10
Remote Start
Trace ID
Auto Record Length to 25 ft.
8 Inch Wide Recording Width
Timing Lines
High Gain and Medium Gain Inputs

Closed Circuit TV System:

This system consists of four remote TV cameras, three video recorders, five permanent monitors and additional monitor drive capability. There are 10 locations for cameras on the tunnel skin as identified in Figure 2(a).

The cameras have tilt, pan and zoom capability. This system is for safety and general visual monitoring of the model during testing.

Acoustic Recording System:

Several portable analog 14 track and one 32 track intermediate band tape recorders, B&K capacitance microphones and supportive instruments are available to record acoustic data.

Auxiliary Instrumentation

In addition to the systems previously discussed, the usual portable instruments are available. These include oscillographs, frequency counters, digital voltmeters, strain gage power supplies, and bridge balance boxes.

Special Requirements

Instrumentation and control system electronic power must be obtained from the special instrument power outlets in the control room. If these systems are grounded to equipment which are not connected to the model, the mounting-strut/fairing foul system will not operate. (See discussion on balances, above).

Wires from the model to the junction box must be 80 to 90 feet long, depending on which main strut they go down. There are no provisions for running leads in the tail strut fairing. Shielding against electrical noise is very important in such long wires. The FHW staff should be contacted regarding shielding requirements. This problem and several solutions are discussed in Instrumentation Grouping and Noise Minimization Handbook, AFRPL-TR-65-1, pg. 18. In general, data wires should consist of twisted, shielded pairs with the shields insulated. Thus, each shield can be grounded at its appropriate point.

Model and Flow Visualization

Facilities for model illumination are provided. Normally, the model can be observed during tests from either side and from above the test section. When safety demands it, most of the direct viewing windows will be covered with armor plate, up to four closed circuit television circuits will be provided for visual monitoring of the model; three of these can be continuously recorded on video-tape.

Data Reduction

The 40- by 80- Real-Time Data Acquisition System, as outlined under Instrumentation, is composed of subsystems under the control of the DEC 11/70 DGP computer. The system acquires data in the three modes of on-line operation, hardware verification, monitor, and record.

Hardware Verification Mode:

Data is acquired and displayed in raw counts. This assists the technicians in problem determination and system end-to-end checkout.

Monitor Mode:

Data is acquired from Toledo Scales, special instruments, miscellaneous analog signals and factor table which can be reduced and displayed without hard copy.

Record Mode:

Data is obtained from all subsystems on-line and written to disk. For efficiency of wind tunnel operation and safety, selected data (force, moment, pressure and special instruments) can be reduced and printed only and/or displayed in monitor mode. Dynamic data will be recorded, but not reduced on-line.

Data Reduction Programs:

The force and moment data are normally reduced on-line by the FHW VAX 11/780 REP computer. Located in the office area is a remote link to the Central Computer Facility.

Data reduction programs for the force and moment data applicable to aircraft, helicopter, and propeller test models are available. These programs produce tabulated aerodynamic coefficients, and may be computed about any of the commonly used axes. Pressure data can be reduced to (P-Ps)/q or P/q type coefficients, and integrations of these can be performed by available programs. Data reduction other than pressures and dynamic data beyond existing programs must be provided by the contractor or specified according to Appendix A. All contractor furnished data reduction programs must be completely debugged and checked out on the computer to be used at least one week prior to tunnel test date.

For guidelines for preparing test write-ups for software support, see Appendix "A".

MODEL REQUIREMENTS

Reliability

There is always a large backlog of urgent work for this wind tunnel. It is especially important, therefore, that models and their instruments be reliable so as to avoid delays and repetition of runs.

Environment

The ambient temperature in the tunnel is uncontrolled and varies with the seasons from as low as 30°F to as high as 120°F. During a test run, the tunnel temperature may increase as much as about 30°F with unpowered models. Test runs with internal combustion engines operating are terminated when the tunnel temperature reaches about 130°F. The model structure and the mechanisms and instrumentation within the model must function reliably over this temperature range. Particular attention must be given to protection of instrumentation and wiring in proximity to engine combustion and exhaust systems.

The total pressure of the air stream is atmospheric at all speeds. The static pressure and the dynamic pressure are those resulting from adiabatic flow from atmospheric static pressure and zero speed. The density ratio, temperature ratio, and stream velocity are shown as functions of the dynamic pressure in figure 15.

The tunnel air speed is determined from the pressure difference between a static pressure ring at the entrance of the contraction cone and one in the test section at the minimum cross-section station. This pressure difference is measured as uncorrected dynamic pressure on a force scale. The data is corrected according to the tunnel calibration by the standard computer program. Tunnel total temperature is recorded from a resistance thermometer located ahead of the entrance cone and is considered constant throughout the tunnel circuit.

Size Limitations

Span:	72 feet (maximum test-section width, 79 feet)
Wing area:	Approximately 600 square feet
Length:	60 feet
Weight:	70,000 pounds (additional restrictions when using alternate support systems)

The first two items are governed by the reliability of blockage and tunnel-wall corrections necessary for the reduction of the data. If exceeded, results will be questionable. The wind-tunnel staff should be contacted for advice for any contemplated models which would exceed these limitations.

Model Power and Control

Models are controlled from the control room located on the second floor of the wind tunnel test chamber. Provision has been made for power cables, fuel lines, and control leads within the primary support system struts. Ames will supply all fuel lines and heavy electrical power leads up to the model. The Contractor shall supply leads for control units and the control panel. These leads must be 80 to 90 feet long (as also specified for instrumentation wires). Since the space available for leads within the struts is limited, all proposals for use of fuel, power, and control should be forwarded to the FHW staff, together with the needs for instrumentation, for approval prior to fabrication of the lines and cables. It is generally necessary to divide these leads among the two main struts and this should be considered when designing the point(s) of entry into the model. To reiterate, there are no provisions for running leads in the tail strut fairing. Fuel lines and electrical leads carrying any significant voltage must be well separated within the model and shall enter the model via different struts.

Starter requirements for models using jet engines should be discussed with the FHW staff as early as possible. Electric starter power is available for moderate starting torque requrements. Special arrangements must be made in each case for air-start systems.

Leads for Pressure Data

Plans for obtaining pressure data from surface orifices, rakes, and probes should be discussed with the FHW staff at the earliest possible date. Ames can usually supply the required scanivalves and leads to the model. The Contractor will be required to provide leads to the point(s) of mating and compatible with Ames equipment. The mating point(s) shall be either inside the model or at least 80 feet from the model (see discussion regarding instrumentation wires). Connections to the scanivalve units require 0.063-inch I.D. flexible tubing.

Information to be Supplied by the Contractor

Drawings - Preliminary drawings or sketches should be submitted for comments at the earliest possible date. Final drawings showing all details of model construction, and details of all supporting equipment furnished by the Contractor, shall be delivered to the Ames FHW staff no later than the model. Any instructions helpful in the assembly and use of the model shall be included.

Computing information - All areas, moment arms, moment-center locations, tail lengths, mean aerodynamic chords, spans and other geometric information needed for computing coefficients or analyzing the test results shall be supplied not later than the model-delivery date. All pertinent reference data, such as the incidences of all wing and tail surfaces, locations of pressure orifices, and so on, shall be included.

Templates - Templates suitable for checking the contours of any surface which may be subject to change during the investigation and for setting and checking the angles of all movable or adjustable surfaces shall be delivered with the model.

Calibrations - Calibrations of all Contractor-furnished instrumentation such as strain gages or position indicators shall be delivered at least as early as delivery of the device itself. It is the policy of the FHW staff to check these calibrations and to check the functioning of all such devices before installation in the wind tunnel. The Contractor shall furnish loading yokes, gages, or other equipment needed to facilitate such checking.

Attachment pads - Model attachment pads conforming to the typical arrangement shown in figure 7 shall arrive at the laboratory no later than three weeks before the model is scheduled for the tunnel. With the arrangement shown in figure 7 approximately 22.5 degrees angle-of-attack is possible. If a greater range of angle-of-attack is required then wedges similar to the diagram shown in figure 7 are necessary.

Fuel requirements - The type, quantity, and flow rate of fuel required for the operation of internal-combustion engines shall be made known to the FHW staff at the earliest possible date. The costs for such fuel are to be borne by the Contractor or the sponsoring agency.

Safety analysis - A safety analysis report is required. (See the System Safety Analysis section.)

Delivery

Models, complete in all respects and associated equipment and information shall be delivered in advance of the scheduled test date, allowing sufficient time for checking the model, calibration or instrumentation, assembly, and installation and/or checking connectors on electrical wiring and pressure leads. The length of time required will vary with the complexity of the model.

Contractors shall ship models and component accessories in crating or pallets of adequate strength to withstand unloading by fork lift or crane. Shipment by truck should be on flat-bed or open top trailer to allow access by overhead crane. In the case of large or heavy pieces, suitable lifting points with attachments for cable shackles shall be provided by the Contractor.

For lifting the model into the test section, the Contractor shall supply three lifting points on the model with the center-of-gravity of the model contained within the three points. He shall furnish suitable attachment hardware and special slings, if required, to provide a factor-of-safety of 3 on yield for the lifting system. General hoisting gear, cables, and slings may be provided by Ames and should be discussed with FHW staff before shipment. The burden of shipments to and from Ames rests with the Contractor.

Unpowered Models:

Delivery of the models must be at least two weeks prior to test date.

Powered Models:

Models incorporating power systems for primary (lift/thrust) or auxiliary purposes (such as for boundary-layer-control) must be functionally checked before tunnel entry. If electric motors are used, the functional checks will be made in the model preparation area. If internal-combustion engines are used, the model will be mounted on the Ames Outdoor Aerodynamic Research Facility (OARF). In the latter case, consideration will be given to the advisability of mounting the model on load cells and recording test data at zero airspeed conditions. Thrust calibration, ground effects, noise measurements, and control effectiveness data can be made at this facility which may usefully supplement the wind-tunnel test program and/or reduce the test time required in the wind tunnel. The time required to accomplish functional checks on powered models will be at least three weeks, but will be determined for each model in consultation with the FHW staff.

TEST PROGRAM

General

There is a continual demand for occupancy time in this wind tunnel and test programs are scheduled at least six months in advance. Occupancy time for each program is assigned on a calendar-day basis, not by tunnel operating time. Hook-up and calibration time, time to make model configuration changes, possible delays associated with model and tunnel equipment malfunctions, instrumentation problems, etc., all reduce the amount of time available for testing. The wind tunnel normally operates two shifts per day, five days per week. Thus, it is necessary to plan each test program carefully for the best use of the allotted time.

Schedule of Tests

The Contractor shall submit a preliminary schedule of proposed tests at least one month in advance of the scheduled test date for review by the FHW staff. It is advisable to assign priorities to the proposed test conditions to aid in formulating the final test schedule, and also to assure an efficient chronological scheduling of test runs in the event of unusual delays in the progress of testing or failure of the model before the tests are completed. All proposed test runs shall meet with Ames' approval in preparing the final test schedule.

Authority During Test Operations

During actual test operation, the Project Engineer or his assistant(s) shall supervise the testing. Authority to deviate from the approved test schedule rests with the Project Engineer alone. The Project Engineer, Assistant Project Engineer, or Contractor (on a contractor supported test) shall have the authority to limit or terminate a test run should safety or integrity of the model appear to be in desgin.

Treatment of Data

There shall be continuing and free exchange of data gathered by Ames and by the Contractor during the tests. Ames will assume technical ownership of <u>all</u> data (including photographic coverage) and the rights to publish the data through the usual NASA procedures unless specific agreements to the contrary are made prior to the tests. The intent of this statement is to place the burden of disclosure of all proprietary and/or classification restraints upon the Contractor. Early discussions of such restraints will assure preparations for any requirements for special handling of the data and will allow Ames to properly assess its position in support of the proposed program.

SYSTEMS SAFETY ANALYSIS

A safety engineering analysis of a proposed test system, operating within prescribed test envelopes, shall be made in sufficient depth to assure maximum safety consistent with operational requirements. The extent of the analysis required will vary widely according to the nature and complexity of the potential hazards in each specific test system. A meeting shall be held with Ames FHW at the earliest practical date to establish the exact safety analysis requirements for the system proposed. The results of the analysis and changes and/or modifications made in the test system to meet the requirements must be submitted in writing to the FHW staff and approval obtained 30 days prior to scheduled entry into the wind tunnel.

Each test system must be reviewed in detail to disclose all safety considerations pertinent to the specific system. A test system encompasses the model and its components, interfacing subsystems, equipment, instrumentation, and test crews. Facets involved in a system safety analysis are outlined below. Because of the variety of proposed test systems, these cannot be regarded as either complete or applicable to each test. The specific requirements to be met must in each instance be established by agreement with the FHW staff.

Gross Hazard Study

A gross hazard analysis shall be conducted. This study is a comprehensive, qualitative, non-mathematical assesssment of the safety features of the test system. Areas to be considered may include, but not be limited to, the following:

1. The complete model design shall be reviewed to identify all critical elements which must be subjected to detailed loads/stress analysis. This shall be done as early as practical in order to obtain NASA approval on 1) the scope of the analysis, 2) whether steady-state or dynamic considerations shall dictate the nature of the analyses, and 3) the particular analytic techniques to be used (see Specific Requirements).

2. Identification of energy sources, including those that might be released in the event of model failures (see Specific Requirements).

3. Fuels and propellants: Their characteristics; hazard levels; handling, control, and usage safety features (see Specific Requirements).

4. Proposed system environmental restraints, e.g.:

   a) Remote control of power and controls.
   b) Response times of variable parameters.
   c) Limited visibility of test model.

5. Human factors, e.g.:

   a) Familiarity of operators with the test system.
   b) Interfaces between NASA/Contractor personnel.

c) Interfaces between disciplines (operator/aerodynamicist/dynamicist/technicians) including the "language barriers".
d) Divisions of responsibility and authority under emergency situations.
e) Training pertaining to safe operation and maintenance of the system (see Specific Requirements).

6. Probable nature and impact of system equipment failure including model power and controls, and tunnel drive and attitude controls.

7. Compatibility of material including such considerations as:

a) Proximity of fuel and electrical wiring.
b) Temperature environment on instrumentation sensors and lead wires.
c) Deleterious effects of leakage of fuel/lubricants throughout the system.
d) Toxic materials identified and safety provisions made.

8. Hazards to procedural changes, e.g.:

a) Deviating from a specified test schedule.
b) Deviating from a specified test start/stop procedure.
c) Importance of monitoring specific test parameters (such as instrumented stresses, loads, positions, speeds, powers): Which are required to be functioning properly for safe operation.
d) Changes in crew such as altering the number of operators/monitors, changing crews while a test is in progress, at shift change time, or providing temporary substitutes for specific tasks.
e) Improper procedural action by operators.

9. Sequential failures: With an assumed initial failure, the system shall be analyzed for hazards in the failed system, interfacing subsystems, equipment, and components; and shall include the effects of probable operator's reactions to the initial failure.

Specific Requirements

Model Strength:

1. Steady-state loads - All critical elements of models shall have a safety factor of no less than five (5) on the ultimate strength for all modes of failure; i.e., tension, shear, bending, torsion, buckling, etc. The safety factors are to be applied to the maximum anticipated combined steady state loads. Static tests of the strength may be substituted for complete analysis when desired, and they may be required by the FHW staff where the reliability of calculation appears uncertain. In the case of production airplanes which have been stressed to the standards of the FAA or the cognizant military authority, only the support attachment hardware need be stressed to the above safety factors. Exceptions will also be made in those instances where it is recognized that normal safety factors are incompatible with other design demands, such as in propeller and rotor blade design. It shall be the responsibility of the Contractor to identify all such cases and to receive NASA approval for these exceptions.

Critical structural elements need to be analyzed at the maximum load point taking into account the various orientations that the hardware will be subjected to during the test.

2. Auxiliary devices - If cables and/or cable-hook assemblies are used either for stabilizing or as load carrying members, they shall have a positive lock or be safetied in a manner such that the hook cannot possibly come loose.

   If the cable tension or preload is crucial, the cable tension shall be specified and a cable tensiometer used to verify that the cable preload is in accordance with the specifications.

3. Dynamic load - In many cases, dynamic modes of model or model component motion, loads and/or stresses will dictate the nature of the strength analysis. Test load limitations may be based on fatigue life under cyclic loading contributions rather than upon yield or ultimate material strength. In such cases, the basis for assigning load limitations shall be clearly described and submitted for approval.

   Allowable oscillating stresses caused by oscillating loads, with or without accompanying steady-state loads, shall be computed as follows:

   a. The mean stress, if any, shall be applied to the proper modified Goodman Diagram to which a safety factor of five (5) has been applied.

   b. The gross allowable oscillating stress shall then be obtained from this diagram.

   c. The allowable oscillating stress shall be obtained by dividing the gross oscillating stress by the appropriate stress concentration factor, if any.

   For flight hardware, it is recognized that the above requirements may be impossible to meet and therefore the following may be substituted:

   a. Fatigue testing of actual components may be substituted for calculations.

   b. Critical parts should be designed, if possible, to provide redundancy so that catastrophic failures do not occur. All critical parts should be strain gauged and monitored closely during testing.

   c. An inspection procedure for those critical parts should be outlined and a maximum run time between inspections must be detailed and adhered to during the testing phase.

4. Pressure systems - Models, support equipment, and test equipment using hydraulic, pneumatic, propulsion, and other systems with operating pressures above one atmosphere (15 psig) are to be designed, fabricated, tested and installed to comply with the applicable codes and requirements listed below.

Elements of systems conforming to one of the following standard codes are acceptable for use provided the test environment is properly considered in the design:

- ASME Boiler and Pressure Vessel Code
- ANSI Code for Pressure Piping, B31.3 and B31.2
- Department of Transportation Regulations

All shells, test chambers, and tanks designed for internal pressures greater than one atmosphere are considered pressure vessels. Also defined as pressure vessels are components for gas transmission at pressures greater than one atmosphere that cannot be circumscribed by a 26 inch diameter circle. Also included are shells, test chambers, tanks, ducts, and pipes with inside diameters greater than 6 inches subjected to net external pressures.

Pressure vessels are to be designed in compliance with the latest edition of the ASME Boiler and Pressure Codes, Section VIII or Section III. The requirements of Section VIII or Section III must be satisfied.

Welding of pressure vessels is to be in compliance with the ASME Boiler and Pressure Code:

- Section IX for Welding Qualifications
- Section V for Welding Inspection

Relief devices are required in the supply system (not necessarily in the model) and are to be capable of discharging the full flow of the pressure source under all conditions including those resulting from malfunctions.

Components are to be indelibly marked, in a conspicuous place, with sufficient information to determine:

- Part number
- Pressure test
- Working pressure
- Date of pressure test
- Volumes and temperature range

Pressure components that have been pressure tested are to be stored in a clean, dry, sealed condition with controlled accessibility.

Pressure vessels fabricated from standard pipe, standard pipe fittings, and standard flanges are also considered pressure piping. They are defined as those covered by the applicable ANSI codes.

Piping is to be designed, fabricated, inspected, tested, and installed in compliance with the latest edition of the ANSI Standard Code for Pressure Piping.

For powered models, the internal supply tubing is considered pressure piping.

Welders, welding operations, and welding procedures are to be qualified in compliance with Section IX, ASME Boiler and Pressure Vessel Code, except as modified by the applicable section of the Piping Code.

Allowances are to be made as required or recommended by the Piping Code for pipe threading, corrosion, thinning of wall due to pipe bending, and pipe tolerances. See the following ANSI Codes:

- Pipe: B36.10 and B36.19
- Fittings: B16.9 and B16.11
- Flanges: B16.5

Threaded joints, flange joints, and seal welding of threaded joints are to be in compliance with the requirements and recommendations of the Piping Code.

Tube fittings are to be in compliance with the latest issue of applicable Military Standard. Because of safety, installation, checkout, maintenance, and operation, it is required that all service lines be properly identified for working pressures, flow direction (in or out), and fluid or gas carried.

Identify all loose lines including spares, shipped separately from the model, and the model interfaces where user's lines and/or lines furnished by others need to be connected. Metal tags attached by wire which is compatible with the piping and/or hose material are required.

Identify the internal lines for all models and model support systems.

5. Rotor and Propeller Tests - Equipment which is to be used for testing rotors and propellers shall have a systems dynamic analysis. The data presented in Tables 1 and 2 can be used to estimate the dynamic characteristics of rotor test apparatus other then the Ames RTA. A shake test is usually required for new configurations of rotor or propeller test hardware.

6. Fire Protection - In models with internal-combustion engines, the Contractor shall supply an integral fire-extinguishing system, or shall contact the FHW staff for advice regarding utilization of the tunnel fire-extinguishing system or the on-board system for this purpose. The tunnel system is of the carbon-dioxide type and is designed to protect the balance room and test section against fuel fires. Auxiliary fittings are provided to which the model lines may be attached. The on-board system is a self-contained system which utilizes bromolriflouromethane as an extinguishing agent and is mounted on the model. The normal detection device used with this system is a combustible gas alarm. The extinguishing agent is released manually. If fire or temperature detectors are desired then the Contractor shall furnish these devices.

   If the model is an aircraft with intergral fuel tanks, these tanks shall be filled with an inert gas under a small positive gage pressure during the wind tunnel tests.

Fragmentation Energy Levels:

The total system shall be reviewed to identify energy sources, especially those that might be released in the event of a model failure. Examples of such energy sources include rotors, propellers, fans, pressure vessels, and explosive cartridges. During testing, the primary dangers to personnel arise from high energy fragments released as a result of such model failures. The energy level, and the range of directions possible, at the time of release shall be documented. The energy level shall be expressed as:

$$e = \frac{W}{A} \left(\frac{V}{1000}\right)^2$$

where,

W = weight of unit, lb.
V = velocity at instant of separation, ft/sec
A = minimum cross-sectional area, in^2

Details of the calculations, and the quantities W, V, A shall be included in the documentation. The data will be judged in terms of the likelihood of injury to personnel. Corrective measures may be required to assure a satisfactory level of personnel safety. Figure 16 is a chart that should assist in making these decisions. The 40- by 80-Foot Wind Tunnel test section is lined with armor plating. The thickness of the plate is 1-1/4 inches on the west wall and 5/8" on the east wall.

Fail Safe Controls:

Loss of primary power (electrical or hydraulic) to model controls can precipitate failures unless fail-safe systems are used; such as self-locking mechanical screws, the use of check valves, or closed-circuit hydraulics. Such fail-safe features are required unless the Contractor can prove that testing will be safe without such features.

Dynamic Stability:

Dynamic stability analyses shall be performed for tests which may involve aeroelastic or dynamic instabilities. A written summary of these analyses shall be furnished for review at least two months prior to the tests. The summary should show the type of analysis, main assumptions used, and the results. The results should include 1) the dynamic modes, 2) the level of stability as the stability boundaries are approached, and 3) loads on critical structural members. In case more information is desired, the detailed analyses shall be available on request. Proprietary rights will be respected.

Envelope of Test Operations:

Boundary conditions for safe test operations shall be determined, and the criteria for each boundary shall be defined. The predicted values of the test parameters most descriptive of the proximity of operating conditions to these boundaries must be presented in the form of graphical plots as part of the required safety analysis report.

Crew Training:

For those test systems where the safety of test operations may at times be dependent upon the experience or reaction times of the operating crew, simulation training may be required prior to the start of the tests. The need for such training and the nature and extent of the training will be established in consultation with the FHW staff.

Safety Aids

All components and equipment associated with possible system failure modes shall be considered for re-design or supplementary aids to enhance test safety. Such methods as the following shall be considered:

1. Redundance such as parallel servos or hydraulics for critical controls, either of which has sufficient power to do the job.

2. Fail-safe features (see Specific Requirements).

3. Automatic warning such as panel warning lights actuated by sensors on limit load, stress, speed, or temperature on critical components.

4. Automatic lock-out in lieu of warning.

5. Instrumentation duplication such as for sensors measuring critical parameters, and in readout displays of these parameters.

Reporting

The required written submittal of the scope and results of the safety analyses may be an assemblage of notes, letters, company memos, etc.; i.e., it is not required that a formal report be especially prepared to satisfy this requirement. In fact, it is urged that results of the various portions of the safety analyses be submitted as they become available, each in the form most convenient or expedient to the Contractor. This will minimize the possibility of a delay in the test date should any changes or extensions be judged necessary by the NASA. The report shall include the static and dynamic analyses (made to establish the model strength characteristics) in the procedures. The Contractor shall be prepared to describe the analytical procedures in their entirety if required by NASA.

Test Readiness Review

Preparation of a standard FHW Test Readiness Review form will be initiated by the Ames project engineer. This form is a safety checklist intended to serve as a guide to assure that all aspects of test operating safety have been properly considered. Ames and/or Contractor personnel will initial and date all items pertinent to the proposed tests and receive Ames management approval before tests will be permitted to start. A copy of the Test Readiness Review form is included as Appendix B.

TABLE 1.—DYNAMIC CHARACTERISTICS OF THE ROTOR TEST APPARATUS OF THE 8-ft STRUTS/60-in. TIPS (MODULE WEIGHT 305000 lb, 12-in. TAIL STRUT TIP)

LONGITUDINAL MODES							LATERAL MODES						
MODE	ω Hz	H g/1000 lb	H in/1000 lb	C lb/fps	C_L lb/fps	M lb	MODE	ω Hz	H g/1000 lb	H in/1000 lb	C lb/fps	C_L lb/fps	M lb
***** NO DAMPERS *****													
BALANCE	1.81	0.19	0.57	1600	690	64000	BALANCE	2.23	0.45	0.88	630	380	55000
STRUT	3.21	0.30	0.28	2000	1400	49000	STRUT	3.73	0.45	0.32	1500	1400	41000
BAL. VERT.	7.3	0.15	0.03				MAST	23.3	3.2	0.06			
MOD. VERT.	10.0	0.90	0.09				MAST	27.7	2.6	0.03			
XB VERT.	14.1	0.70	0.03										
MAST	25.5	3.2	0.05										
***** BALANCE LOCKED *****													
STRUT	2.45	0.47	0.77	685	640	53000	STRUT	2.72	0.99	1.31	310	250	29000
MOD. VERT.	10.0	0.80	0.08				MAST	23.2	2.0	0.04			
XB VERT.	15.3	0.50	0.02				MAST	27.7	1.9	0.02			
MAST	25.5	2.5	0.04										
***** 8 BALANCE DAMPERS *****													
BALANCE	2.04	0.14	0.33	2900	2600	35000	BALANCE	2.41	0.34	0.57	1400	760	17000
STRUT	3.46	0.09	0.07	7900	5700	49000	STRUT	4.01	0.17	0.10	4600	3100	33000
BAL. VERT.	7.3	0.15	0.03				MAST	23.2	3.2	0.06			
MOD. VERT.	10.0	0.90	0.09				MAST	27.7	2.6	0.03			
XB VERT.	14.1	0.70	0.03										
MAST	25.5	3.2	0.05										

TABLE 2.– DYNAMIC CHARACTERISTICS OF THE ROTOR TEST APPARATUS OF THE 15-ft STRUTS/6-in. TIPS (MODULE WEIGHT 305000 lb, 12-in. TAIL STRUT TIP)

LONGITUDINAL MODES							LATERAL MODES						
MODE	ω Hz	H g/1000 lb	H in/1000 lb	C lb/fps	C_L lb/fps	M lb	MODE	ω Hz	H g/1000 lb	H in/1000 lb	C lb/fps	C_L lb/fps	M lb
			***** NO DAMPERS *****										
BALANCE	1.85	0.15	0.42	2400	1400	70000	BALANCE	2.32	0.25	0.46	1800	650	51000
STRUT	4.06	0.64	0.38	1200	770	34000	STRUT	4.43	0.97	0.48	880	720	23000
BAL. VERT.	7.2	0.09	0.02				MAST	23.2	1.9	0.03			
MOD. VERT.	9.9	0.70	0.07				MAST	27.7	2.5	0.03			
XB VERT.	14.1	0.65	0.03										
MAST	25.5	2.5	0.04										
			***** BALANCE LOCKED *****										
STRUT	3.09	0.59	0.61	1200	1100	22000	STRUT	3.32	1.13	1.01	550	300	31000
MOD. VERT.	9.9	0.65	0.06				MAST	23.2	1.5	0.03			
XB VERT	15.2	0.60	0.03				MAST	27.7	2.2	0.03			
MAST	25.5	2.5	0.04										
			***** 8 BALANCE DAMPERS *****										
BALANCE	2.14	0.07	0.15	6100	5100	58000	BALANCE	2.63	0.17	0.24	3100	2200	26000
STRUT	4.22	0.27	0.15	3000	2400	40000	STRUT	4.56	0.40	0.19	2300	1900	27000
BAL. VERT.	7.2	0.09	0.02				MAST	23.2	1.9	0.03			
MOD. VERT.	9.9	0.70	0.07				MAST	27.7	2.5	0.03			
XB VERT.	14.1	0.65	0.03										
MAST	25.5	2.5	0.04										

TABLE 3.—SCALE BALANCE SYSTEM ACCURACY

MEASUREMENT	LEAST COUNT	ACCURACY	
		PERCENT OF FULL SCALE	FORCE OR MOMENT
LIFT	2 lb	0.01	± 10 lb
DRAG	1 lb	0.03	± 5 lb
SIDE FORCE	1 lb	0.02	± 10 lb
PITCHING MOMENT	64 ft–lb	0.09	± 320 ft–lb
ROLLING MOMENT	17 ft–lb	0.01	± 170 ft–lb
YAWING MOMENT	24 ft–lb	0.08	± 122 ft–lb

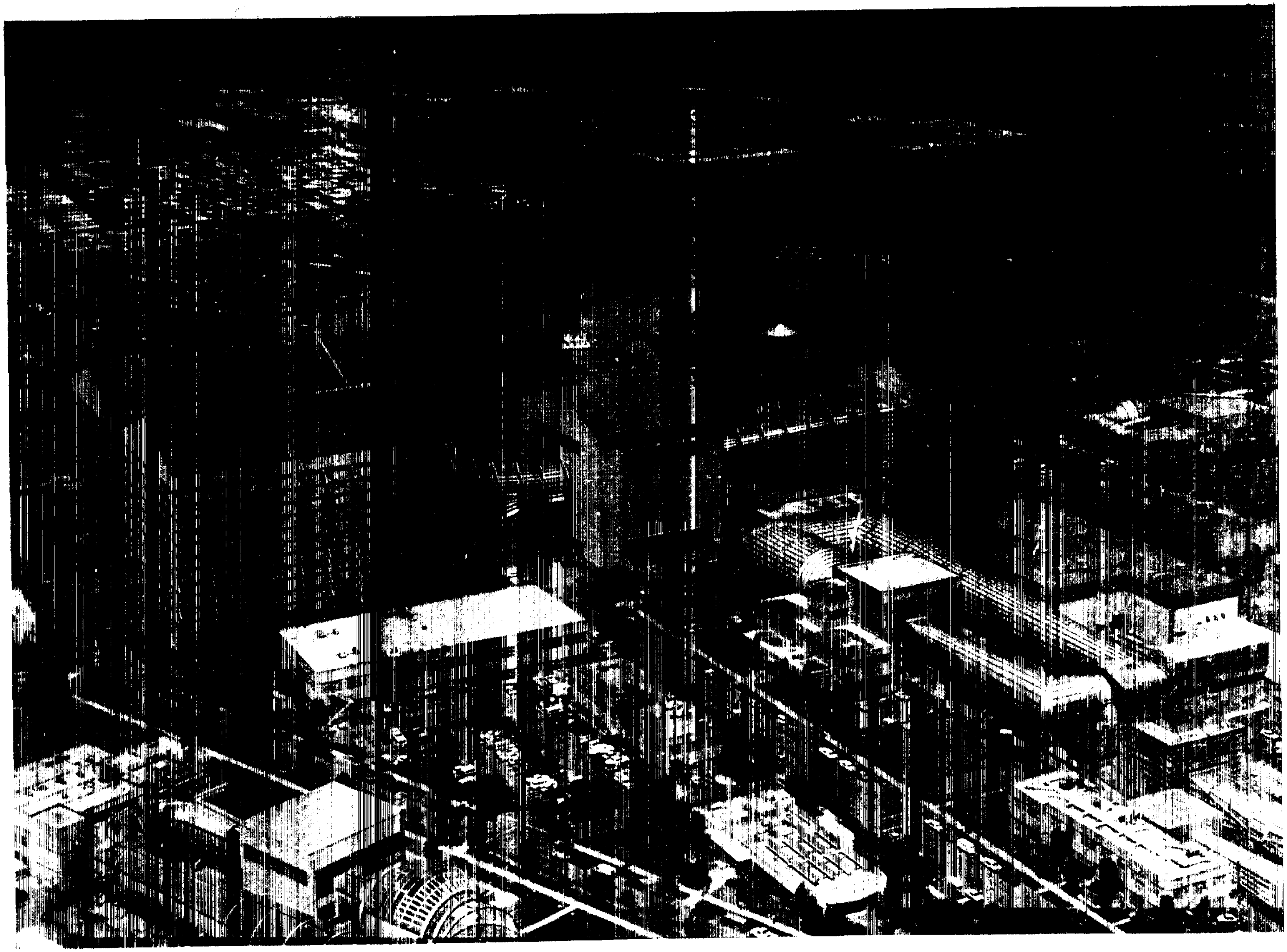
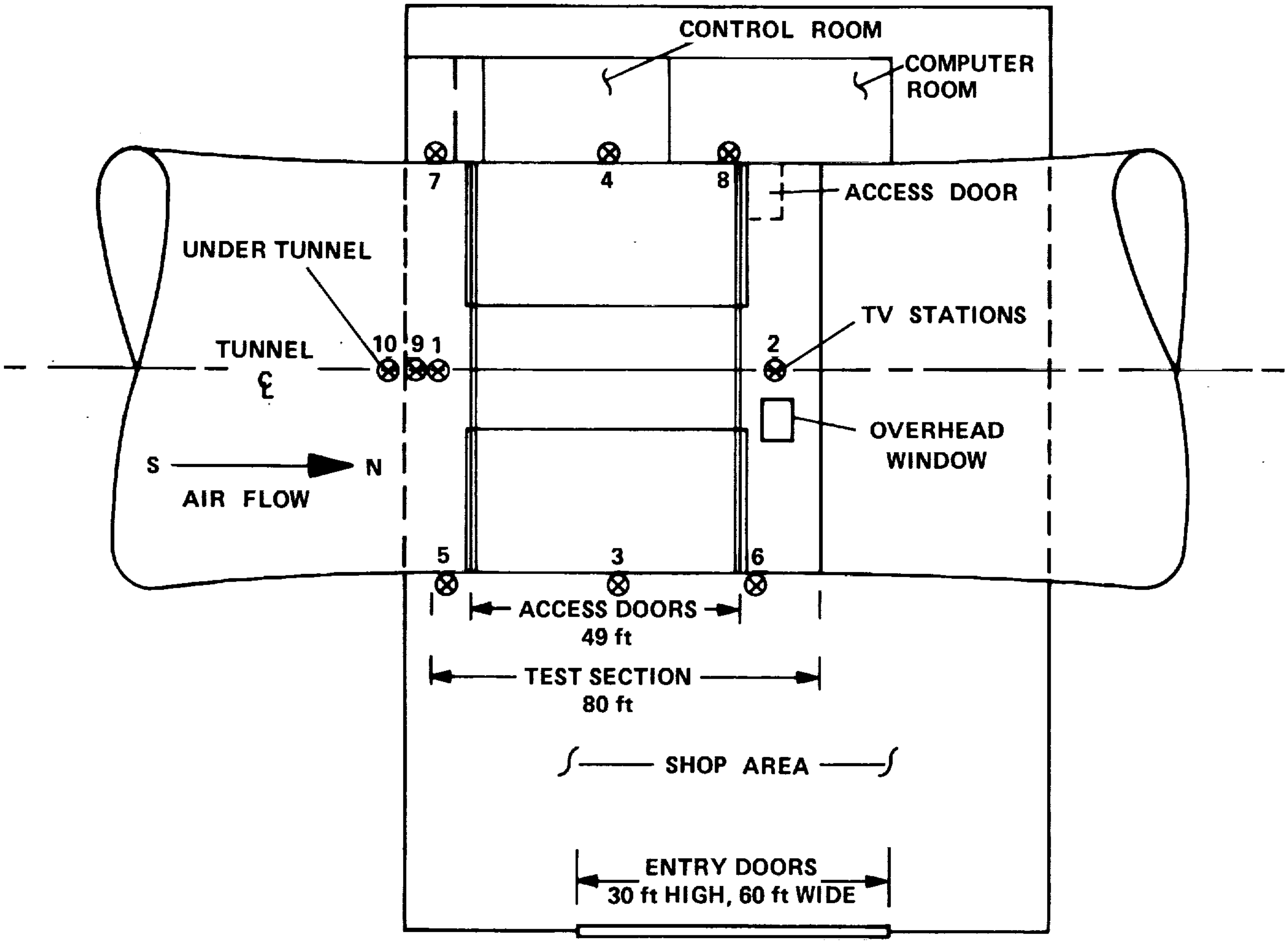
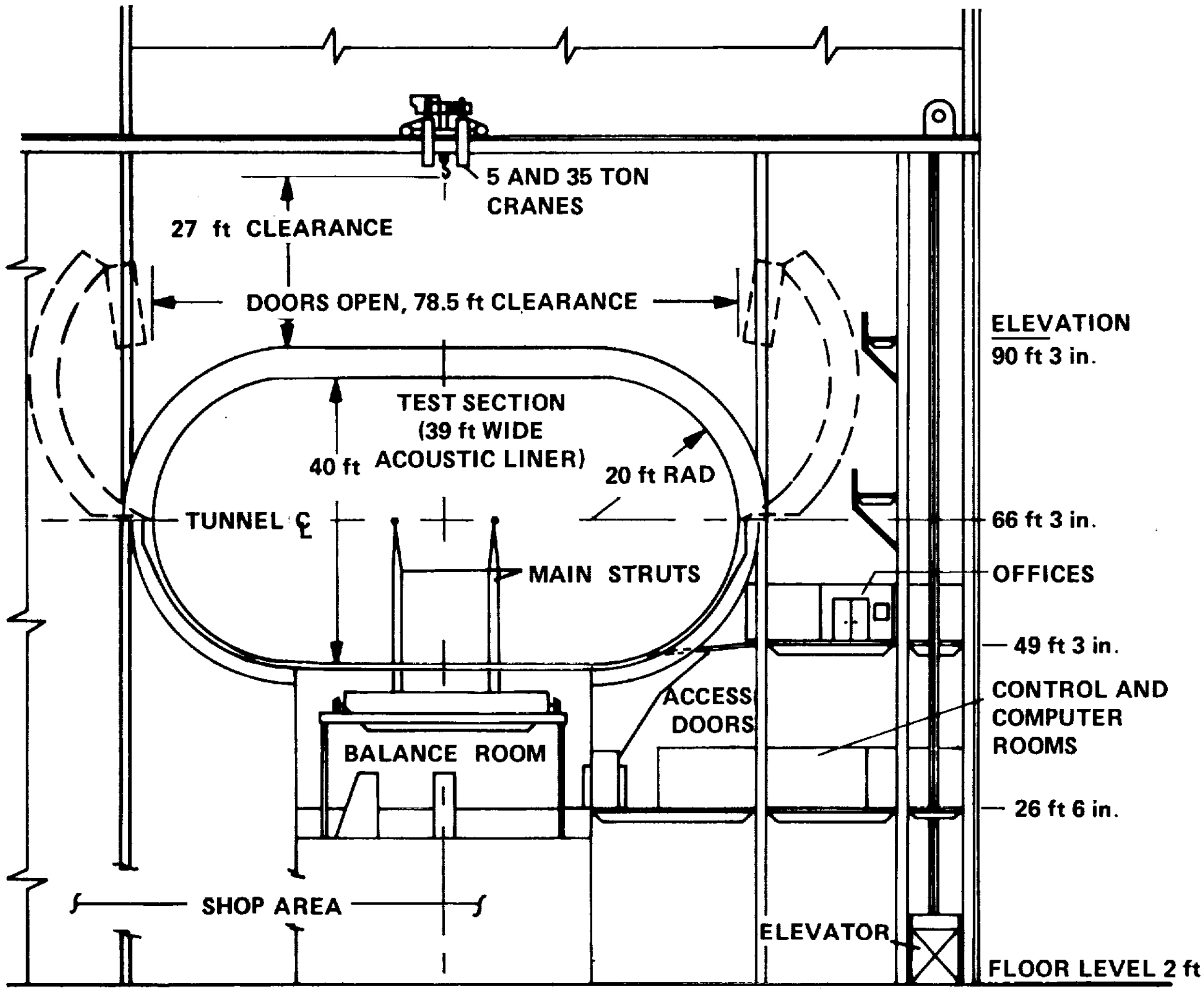


Figure 1.—Photograph of the 40– by 80–foot wind tunnel showing general arrangement.



a) PLAN VIEW

Figure 2.—General arrangement of the Ames 40– by 80–foot wind tunnel test section and shop area.



b) ELEVATION VIEW

Figure 2.—Concluded.

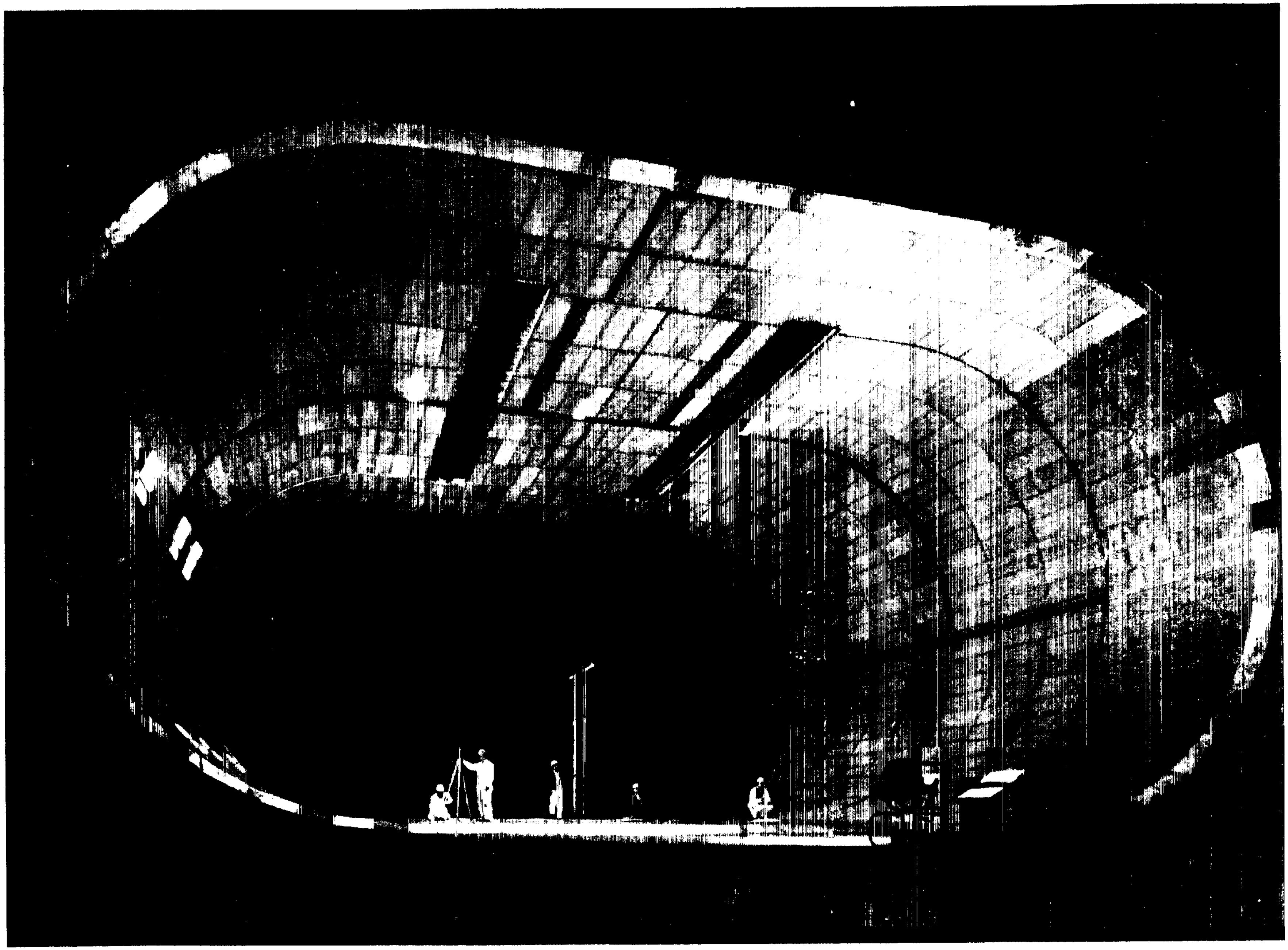


Figure 3.–Acoustic lining installed in test section of 40– by 80–foot wind tunnel.

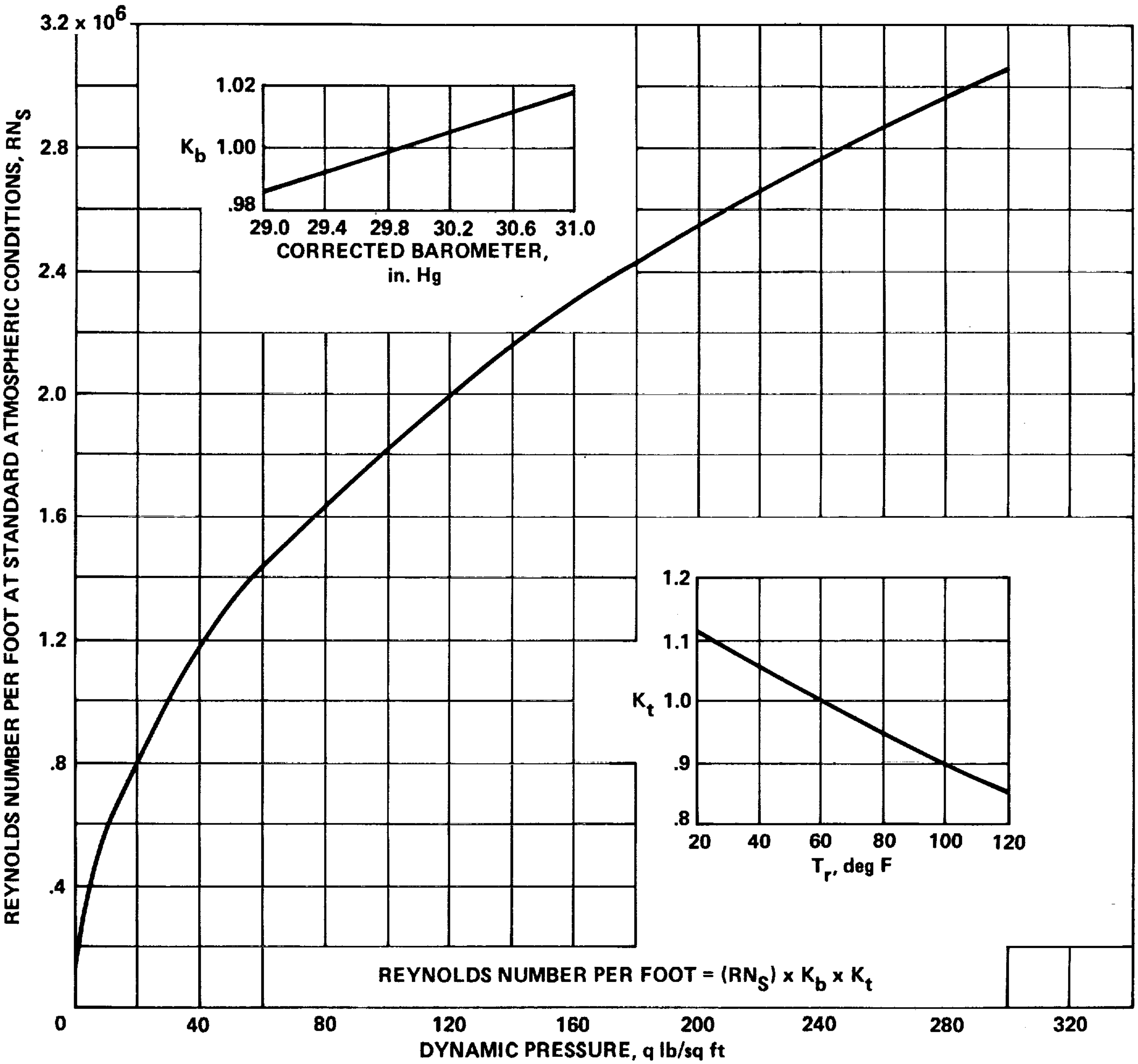
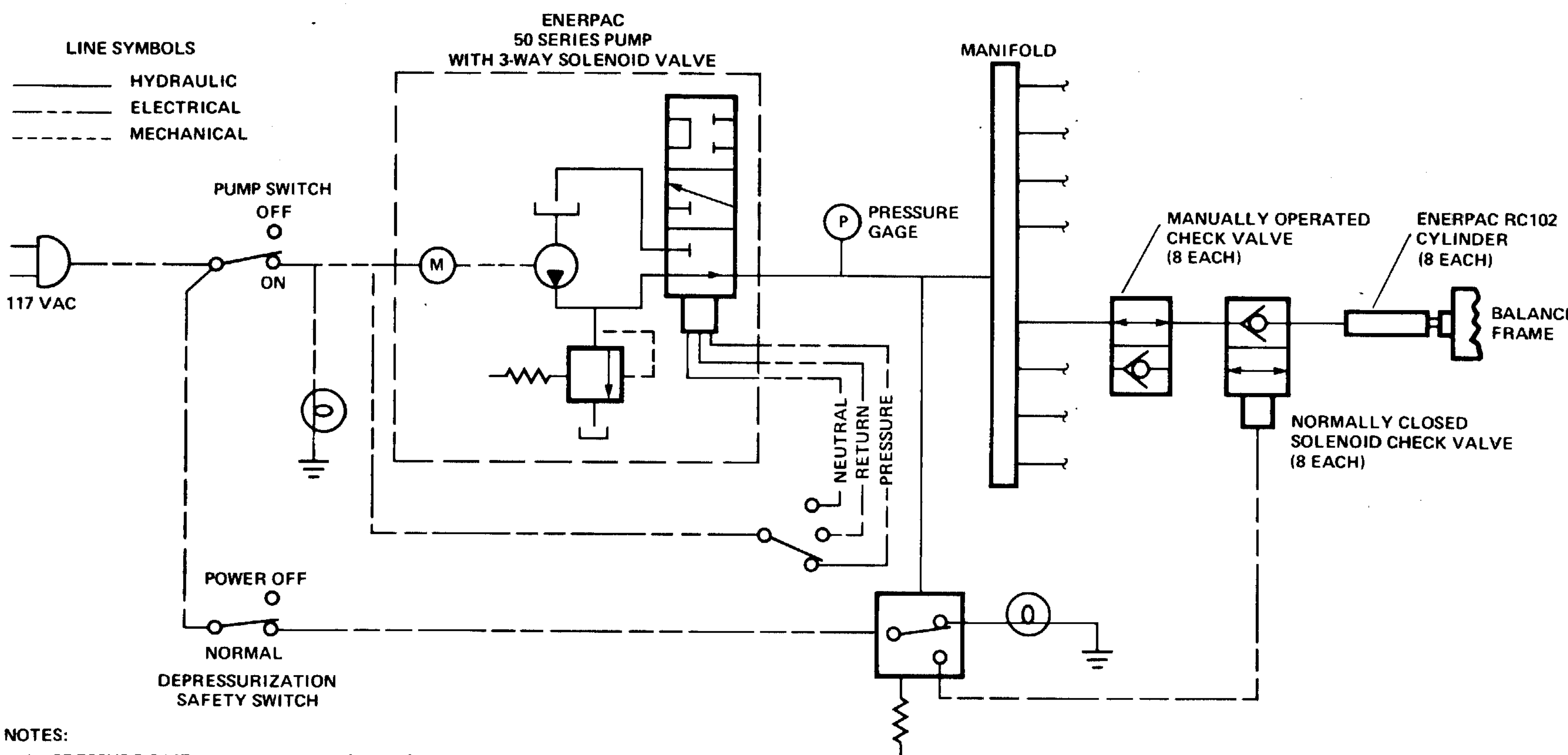


Figure 4.—Variation of Reynolds number with test-section dynamic pressure for the Ames 40—by 80—foot wind tunnel.

TO BE PROVIDED LATER

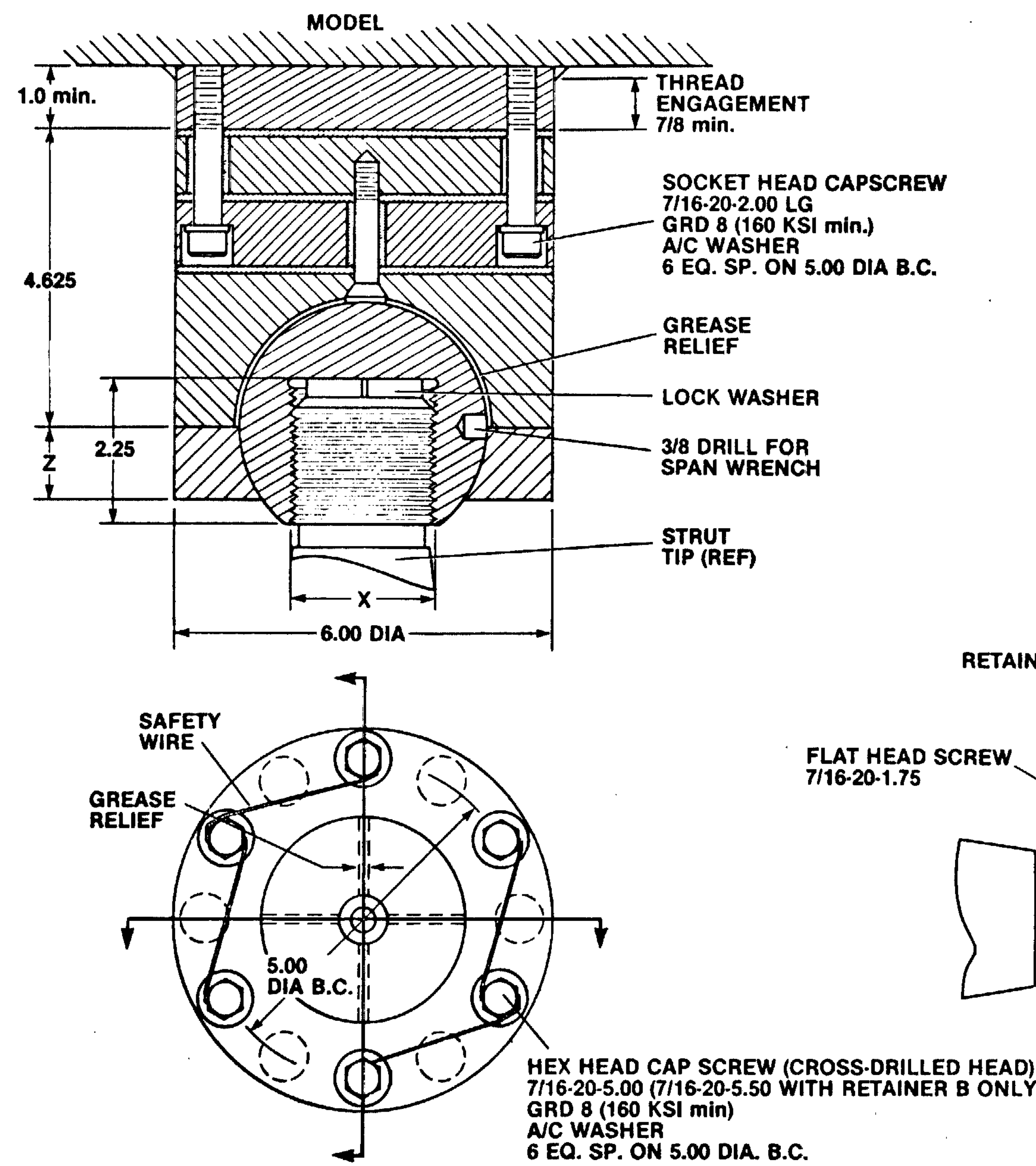
Figure 5.–Wind tunnel temperature rise.



NOTES:

1. PRESSURE SWITCH TO ACTIVATE SOLENOID VALVE AT 5000 ± 100 PSI.
2. READ SYSTEM DESCRIPTION AND OPERATORS' CHECKLIST BEFORE OPERATING SYSTEM.
3. SYSTEM IS DEPICTED JUST AFTER OPERATING PRESSURE HAS BEEN REACHED – PRESSURE SWITCH HAS OPENED, ALLOWING SOLENOID VALVE TO CLOSE.

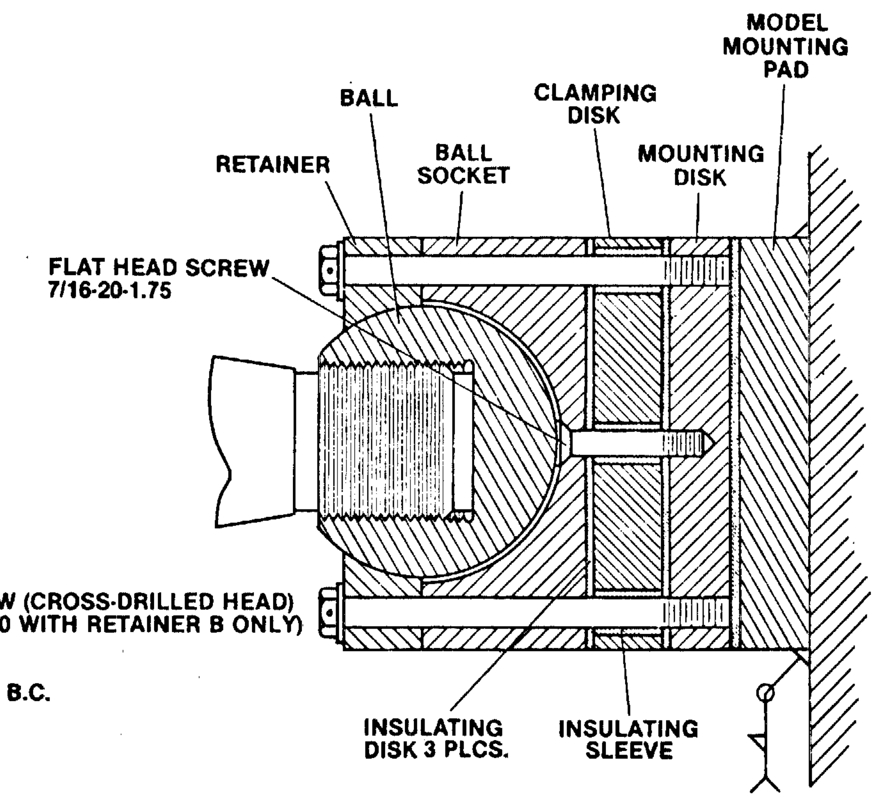
Figure 6.—Balance frame hydraulic snubber system schematic.



RETAINER	DIM Z
A	.625
B	1.062

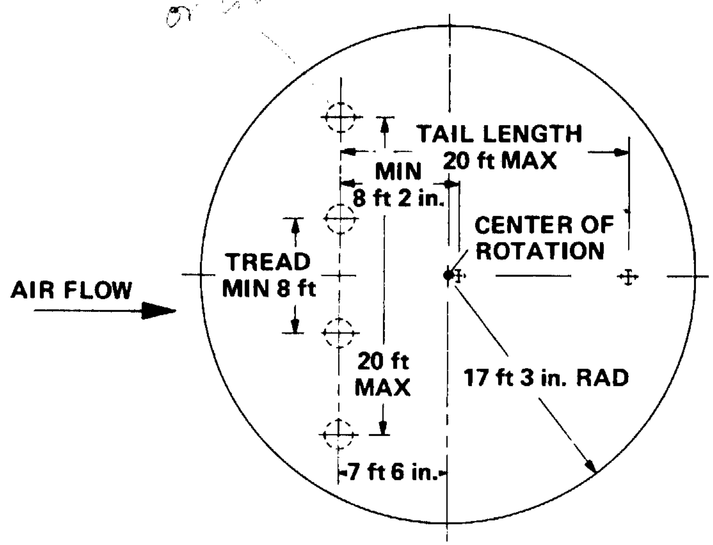
BALL	X
A	2.375 DIA × 12 THD./IN.
B*	1.500 DIA × 12 THD./IN.

*STATIC TEST FACILITY TAIL STRUT ONLY

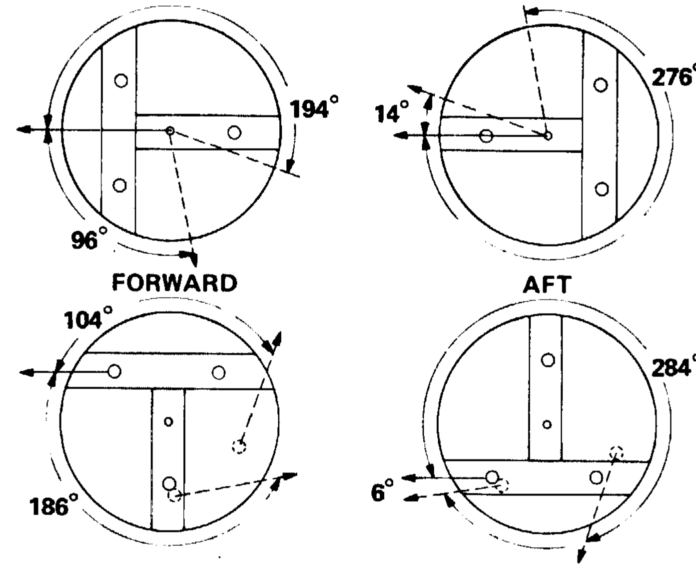


a) GROUND INSULATED MODEL MOUNTING ASSEMBLY

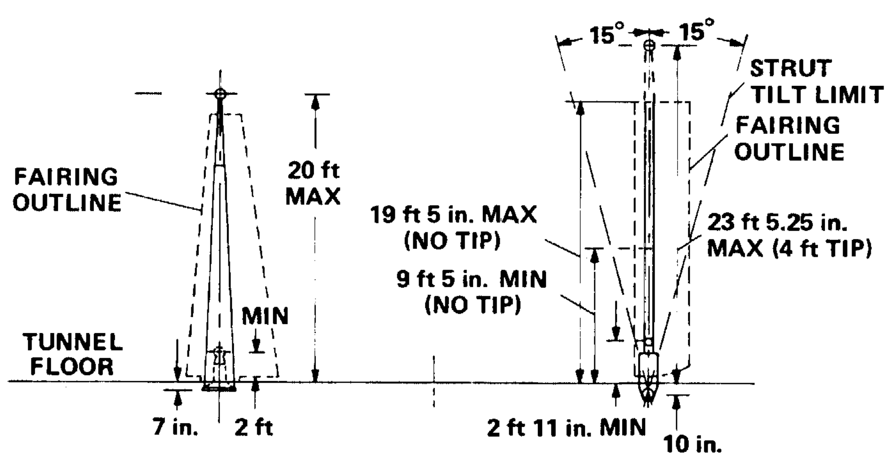
Figure 7.—Primary model support system in the Ames 40 by 80 Foot Wind Tunnel.



TREAD AND TAIL LENGTH LIMITS



YAW LIMITS FOR VARIOUS MAIN STRUT ORIENTATIONS



STRUT HEIGHT AND TILT LIMITS

NOTES

1. Fairings rotate during yawing to stay aligned with windstream.
2. Tail strut tip lengths available are: 12, 24, 36, and 48 inches.
3. Max. tail strut height is attained using 48" tip, 7-foot extension and fairing.
4. Tail strut tilt angle may be limited by interference between model and fairing trailing edge.
5. When the 7-foot tail strut extension is removed to attain minimum height the fairing is also removed.
6. Min & max tail length are with T.S. vertical. Tail strut tilt may be used for some additional length but tilt must accommodate angle of attack range.
7. With model off of struts, main strut and fairing height can be varied increments of 27" from 2 ft to 20 ft from tunnel floor.
8. Main struts have tip lengths of 6", 33", and 60". When using 6" and 33" tips, angle of attack of the model may be limited by interference with the fairing trailing edge.

b) LIMITATIONS OF MODEL TREAD, TAIL LENGTH, AND YAW

Figure 7.–Concluded.

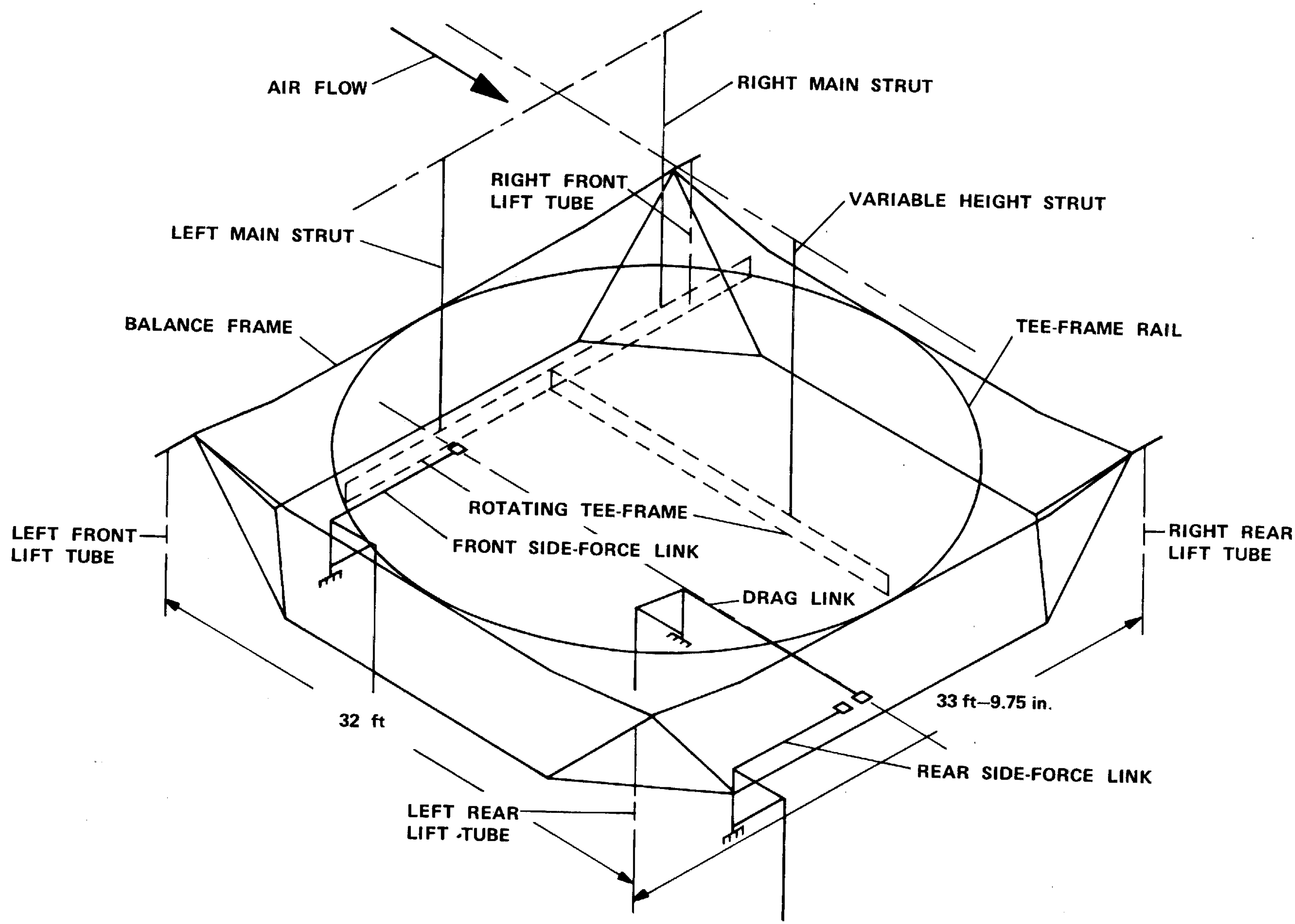
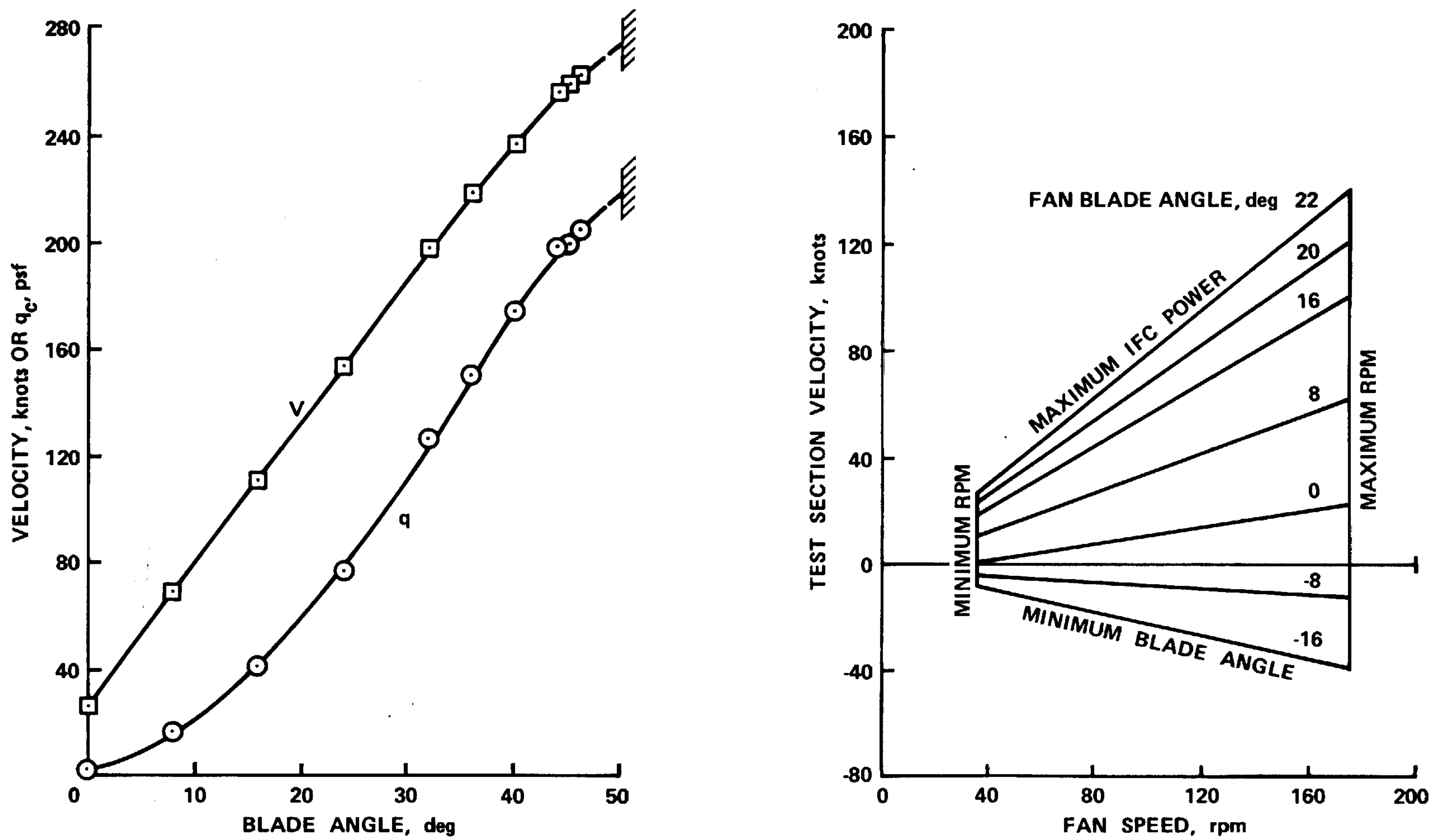


Figure 8.—Schematic representation of the Ames 40— by 80—foot wind tunnel balance system.



a) INDUCTION FREQUENCY CHANGER MODE

b) UTILITY MODE

Figure 9.—Operating envelope for the 40— by 80—foot wind tunnel; test section empty, acoustic lining installed, air exchange louvers open.

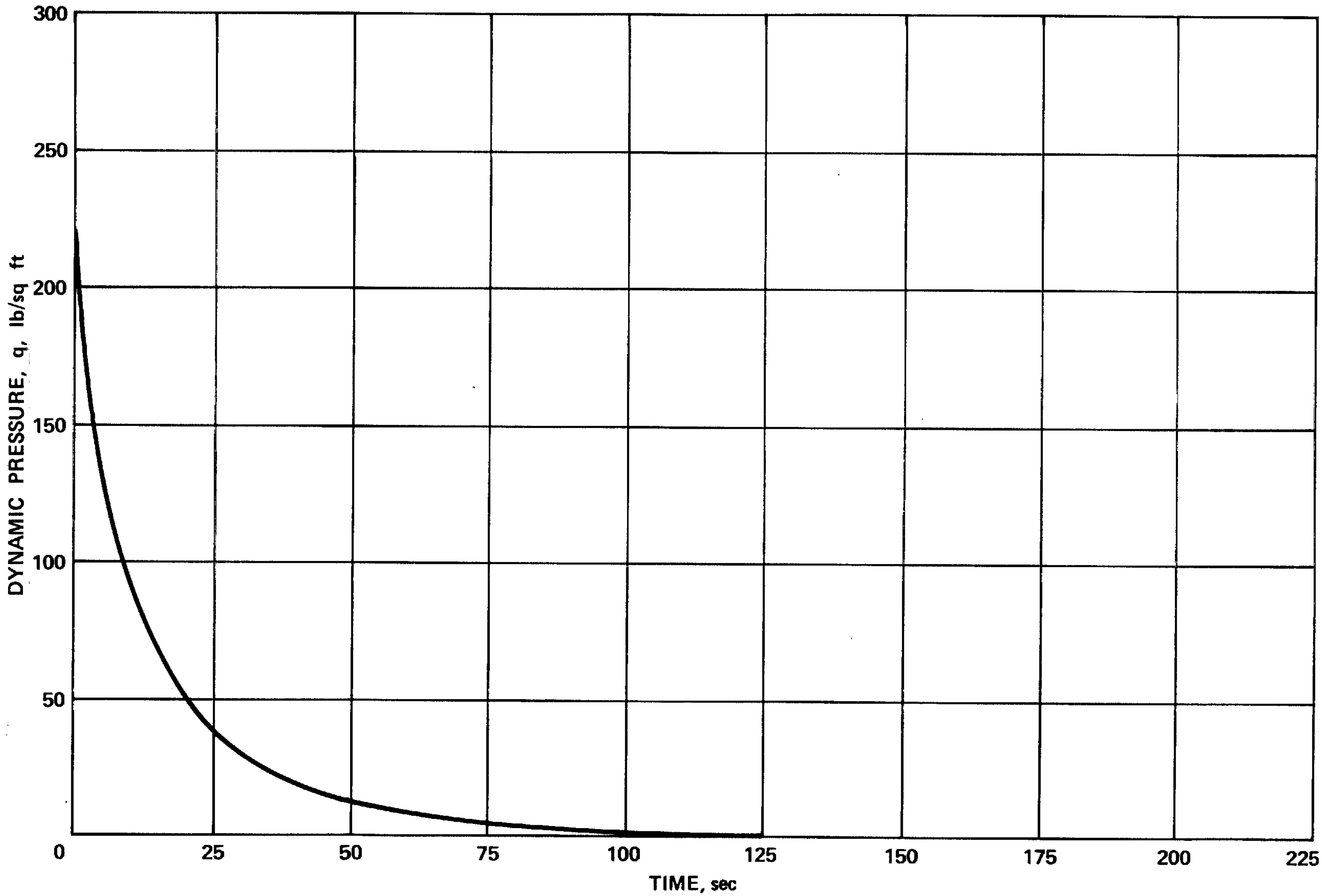
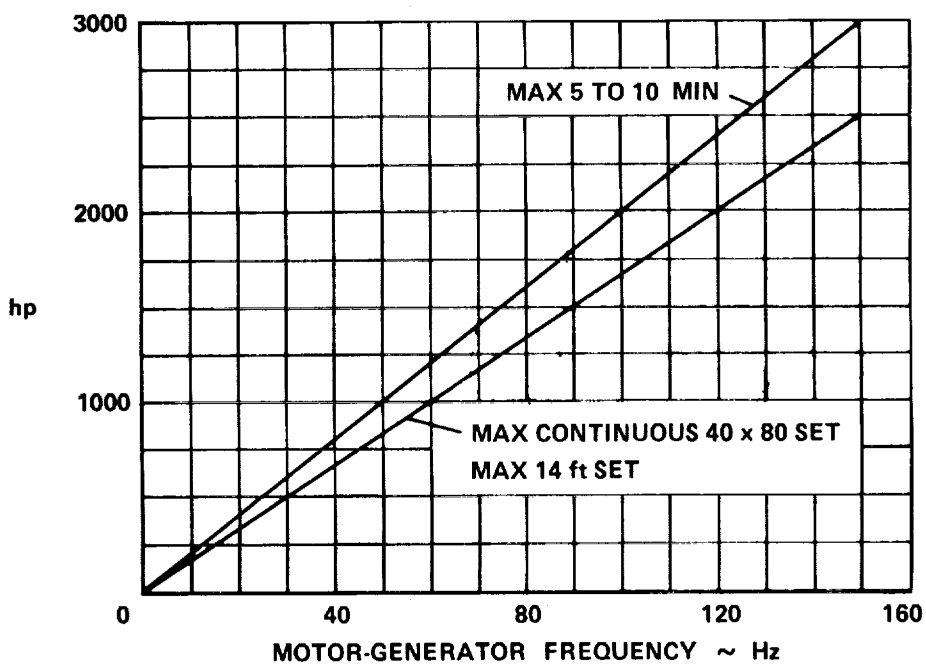


Figure 10.—Dynamic pressure decay after emergency stop.

1. 40–BY 80–FOOT W.T., 150 CYCLE SET
   A. MAXIMUM CONTINUOUS - 2500 hp @ 150 Hz
   B. MAXIMUM - 1. 3000 hp @ 150 Hz
                2. 2350 A, M.G. SET LOOP CURRENT
                3. 90°C (194°F) M.G. SET STATOR TEMP

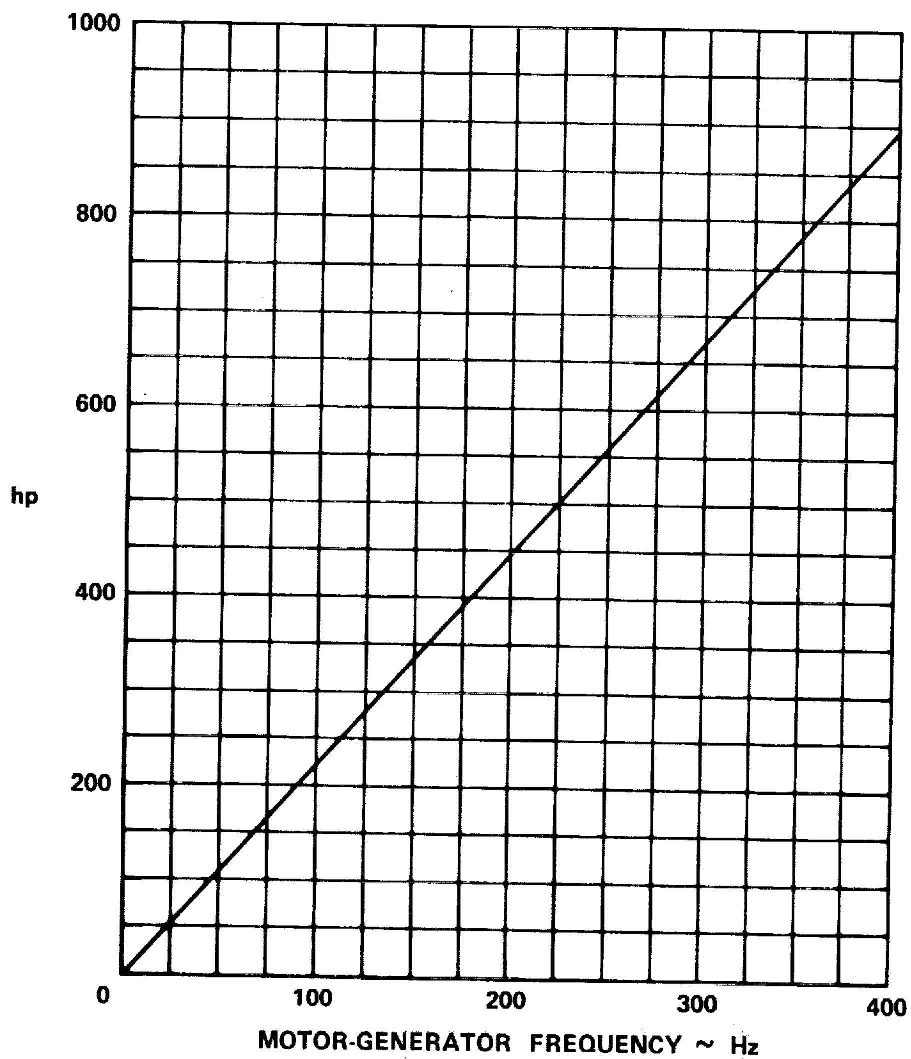
   NOTE: MAX LIMIT IS WHICHEVER OCCURS FIRST OF ITEMS 1, 2, OR 3 ABOVE. MAKE ARRANGEMENTS WITH ELECTRICAL GROUP TO MONITOR ITEMS 2 AND 3 ABOVE BEFORE OPERATING ABOVE 2500 hp

2. 14 ft W.T., 150 CYCLE SET
   A. MAXIMUM 2500 hp FOR 1 hr @ 150 Hz



a) 150 CYCLE

Figure 11.–Operating limits for the 150 hertz variable frequency power.



b) 400 CYCLE

Figure 12.—Operating limits for the 400 hertz variable frequency power.

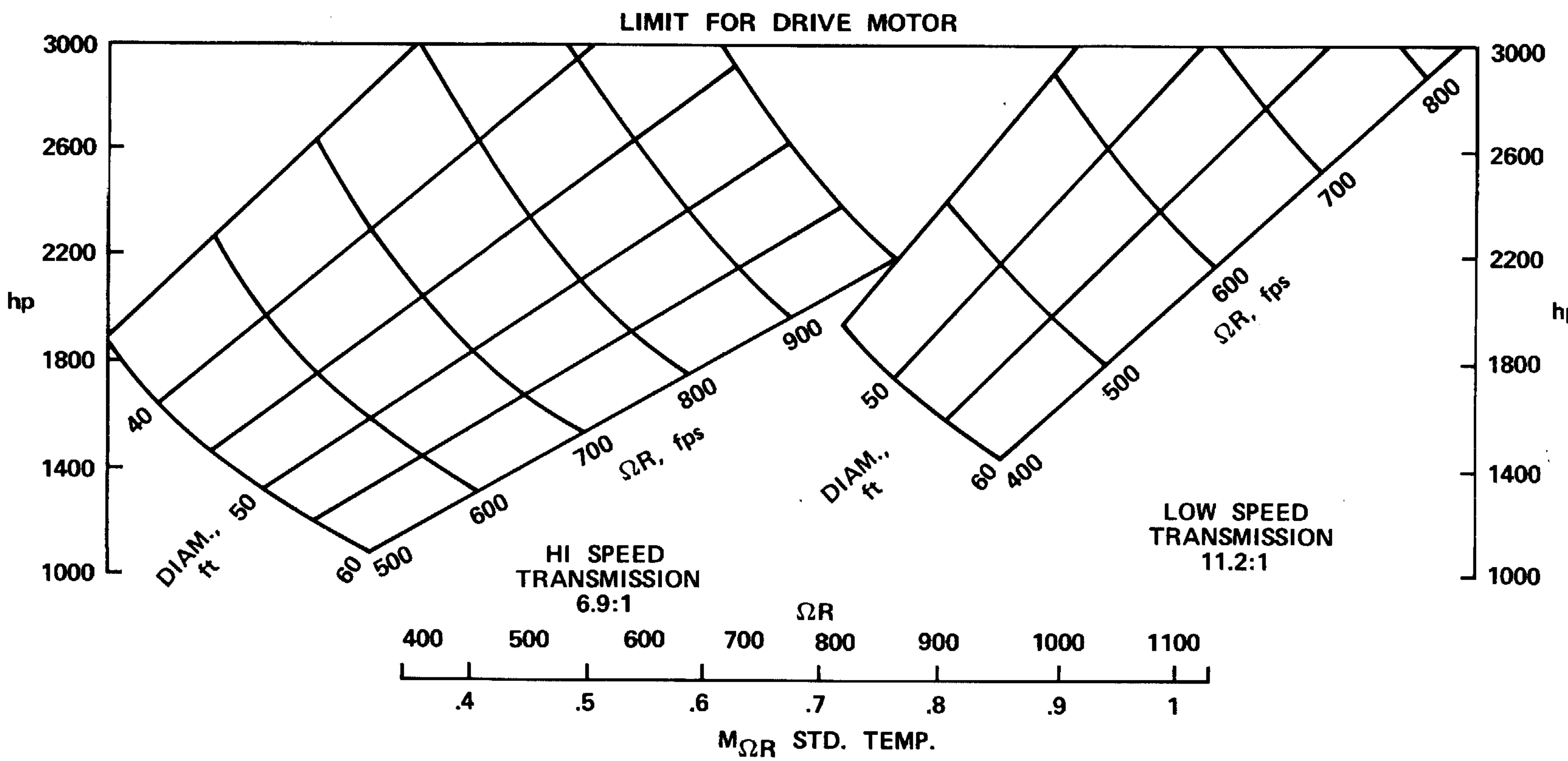


Figure 13.–Power capability – rotor test apparatus.

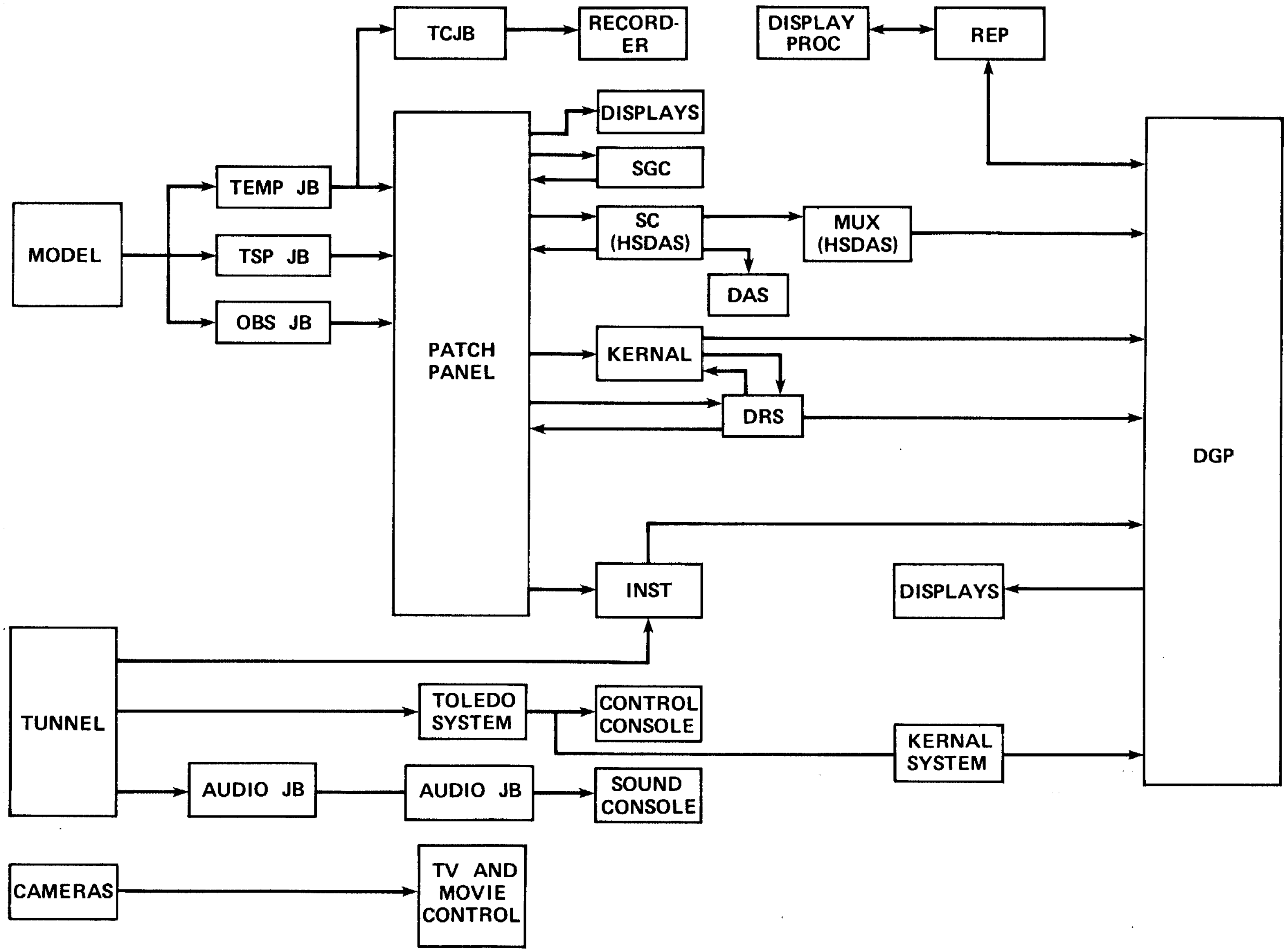


Figure 14. —Block diagram of the wind tunnel data system.

TO BE PROVIDED LATER

Figure 15. —Variation of test-section conditions with test section dynamic pressure at standard atmospheric conditions without a model installed.

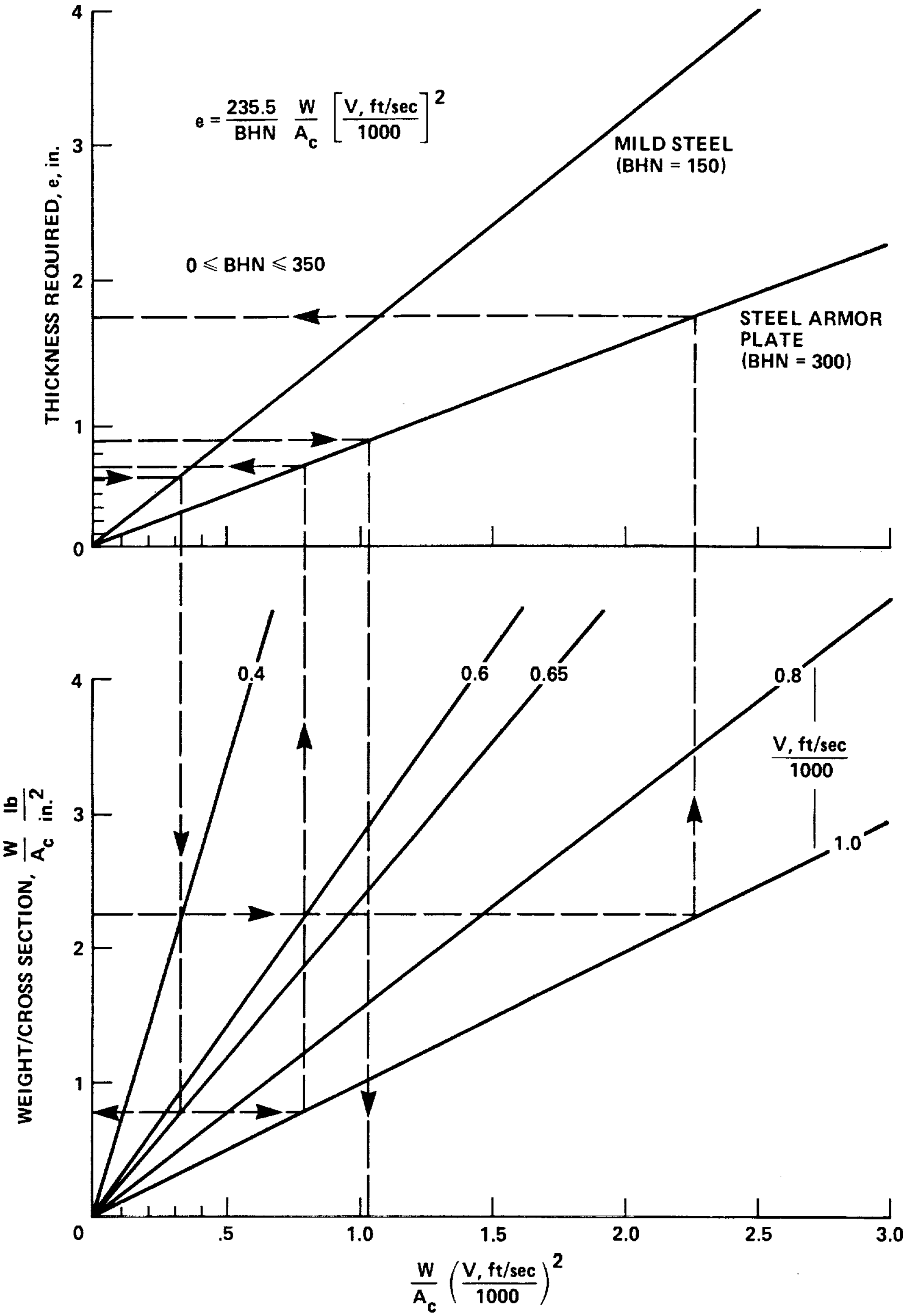


Figure 16.—Chart for determining fragmentation protection.

APPENDIX A

LOW SPEED WIND TUNNEL INVESTIGATIONS BRANCH

GUIDELINES FOR PREPARATION OF

SOFTWARE AND INSTRUMENTATION

TEST REQUIREMENTS

June 1982

Revised January 1984

TABLE OF CONTENTS

1. INTRODUCTION

This document is to be used as a guide for researchers in test planning and preparing their software and instrumentation requirements. By following the procedures and examples set forth, it is expected that the quality of the tests can be significantly improved. This will assist programmers and instrumentation personnel (contract or civil service) in better understanding what is required. The improved organization should also enhance communication between researcher and support personnel during the test. Additionally, it is anticipated that complete and well-defined test documents will eliminate confusion regarding researchers needs and expectations. A well organized set of specifications will enable personnel to develop and implement instrumentation plans and software with as much efficiency as possible.

Many data functions a researcher may require exist as standard software modules. This will be determined during early pretest planning discussions with software personnel. These discussions can minimize the amount of work associated with the following guidelines.

Instrumentation requirements, or information on installed instrumentation, will be submitted on the appropriate form along with software requirements.

2. SOFTWARE

2.1 Lead Time Requirements

In order to assure adequate lead time for software development, three general test categories may be considered:

simple, minimal, or repeat tests which require approximately 3 months lead time, average tests which require 6 to 9 months for preparation, and complex or extraordinarily difficult programs which require 9 or more months lead time.

The lead time requirement is intended to allow sufficient time for all phases of software development. Normally, the actual coding of a program proceeds quickly, but other time-consuming processes must be accommodated, such as: program design, software testing, test case preparation, documentation preparation, computer down-time, and hand checks of computational algorithms. Adequate lead time is therefore crucial to quality development. It is understood that schedule changes and program requirement revisions can result in insufficient lead time, but this problem should be minimized.

As an aid in estimating proper lead time allocations, the chart on Figure A1 is provided. The chart is comprised of five columns representing various components of a program and three rows representing different levels of complexity for each component. Within each box, the circled number represents the number of weeks of lead time to be allocated to any specific component-complexity combination. By totaling up for each applicable component (column), and the weeks assigned to the applicable complexity level (row), the proper lead time in weeks can be determined.

For instance, consider a test of minimal instrumentation (3 weeks) and equations (3 weeks), with complicated table lookups (2 weeks) and average print output (4 weeks) and plotting (8 weeks). The

SOFTWARE LEADTIME REQUIREMENTS CHART

CATEGORY	MODEL INSTRUMENTS (DATA CHANNELS)	EQUATIONS FOR DATA ANALYSIS	TABLE (FOR TABLE LOOKUPS)	TABULAR OUTPUT REQUIREMENTS	GRAPHICS OUTPUT REQUIREMENTS	TOTAL LEAD TIME
MINIMAL	3 WEEKS MINIMAL < 30 TOTAL INPUT CHANNELS AND NO SCANIVALVE INPUTS	3 WEEKS < 20 TOTAL EQUATIONS	0 WEEKS ONLY 1 OR 2 TABLE LOOKUPS	2 WEEKS 1 PAGE	4 WEEKS < 3 SIMPLE x-y PLOTS	12 WEEKS (3 MONTHS)
AVERAGE	6 WEEKS MODERATE > 30 NO. CHANNELS < 40 - NO MORE THAN 10 S/V UNITS	5 WEEKS 20 - 50 EQUATIONS	1 WEEKS 2 - 5 TABLE LOOKUPS	4 WEEKS 2 - 3 PAGES	8 WEEKS 3 - 6 SIMPLE x-y PLOTS	24 WEEKS (6 MONTH)
COMPLEX	9 WEEKS LOADED > 40 CHANNELS OR > 10 S/V UNITS	7 WEEKS > 50 EQUATIONS PER POINT	2 WEEKS > 5 TABLE LOOKUPS PER POINT	6 WEEKS > 3 PAGES PRINTED OUT-PUT PER POINT	12 WEEKS > 6 x-y PLOTS OR 3-d OR CONTOUR PLOTS	36 WEEKS (9 MONTHS)

Figure A1. Software Leadtime Requirement Chart total required lead time is then 20 weeks. In this example, the program requirements would be considered nearly average and the test document should be in the programmers possession 5 months prior to the scheduled test date.

2.2 Submittal of Software Documents

Complete software requirement documents are to be submitted to the Low Speed Wind Tunnel Investigations Branch (FHW) Computational Analysis Group Leader, where they will be reviewed for accuracy and completeness. Thereafter, the approved documents are assigned to an available programmer, who will design and code the software according to the written specifications.

The method of revising the document is discussed later, but all revisions must be submitted to the Computational Analysis Group Leader in writing in order to be considered. Generally, minor revisions are given directly to the assigned programmer and major program modifications are reviewed with group leader.

2.3 Software Requirements Document

The software requirements document authored by the engineer will serve as the sole basis for functional specifications by the assigned programmer. It should be complete and well organized and should contain all information that the programmer may need to be aware of in order to complete the software development task.

The engineer's document should always begin with a narrative description of the research project including objectives of the test, the model under consideration, facilities being used, data systems or any other background material that would serve to aid the programmer in conceptualizing the experiment. Such a description often helps arrange a common basis for future discussions between researcher and programmer.

Data reduction requirements should first be presented in topic sequence or outlined as illustrated in Figure A2. This serves as a quick overview. If plots are requested, they would be included as another section number. Within each section, there will be a unique number assigned to each item or equation, but the outline will serve as a general table of contents. Furthermore, that unique number must be constructed so that the first digit corresponds to the first digit of the section number in which it is initially defined. For example, Item Number 212 would indicate the 12th Item of Section 200.

Additionally, every page of the software document should be numbered sequentially in the upper right corner. This requirement insures the recipient of the document that it is complete, and also aids in revising the specifications (see Section 2.3.6).

Because of the similarities of all rotor wind tunnel tests, there are a number of existing standard data reduction programs to process six component force data from the scale system and dynamic data from the high speed data acquisition system. These standard programs have been completely documented in a manual entitled "Rotor Data Reduction System". This manual guides the user step by step through the computations. It is not necessary for the engineer to provide the equations for these standard computations. Copies of the manual can be obtained from the FHW Computational Analysis Group Leader.

2.3.1 Parameter Numbering

Throughout the test document, item numbers are assigned to each parameter (as in Figure A3a) and each equation (as in Figure A3b). In each instance, the new item has been defined, also indicating units of measure and the range of the value.

TABLE OF CONTENTS

Figure A2. Sample Table of Contents

200. TUNNEL CONDITIONS (NASA INPUTS)

ITEM		
201	V	TUNNEL VELOCITY, XXX.X KNOTS
202	RNFT	UNIT REYNOLDS NUMBER, XX.X MILLION PER FOOT
203	Q	CORRECTED TUNNEL DYNAMIC PRESSURE, XXX.X PSF
204	TT	TUNNEL TOTAL TEMPERATURE, XXX.X °R
205	PTO	TUNNEL TOTAL PRESSURE, XX.XXX PSIA, TRANSDUCER
206	PSO	TUNNEL STATIC PRESSURE, XX.XXX PSIA = PTO - QCV/144

Figure A3a. Parameter Numbering

514 PTFAR - Fan Inlet Average Total Pressure Recovery, X.XXXX

$$= \frac{PTFAV}{PTO}$$

Figure A3b. Equation Numbering

Generally, the programmer will attempt to code the software in such a manner as to make it as consistent as possible with the original document. In such cases, a programmer will use the same name for an item in the program as is used in the document. It is helpful, then, to limit the names to a maximum of 6 characters.

2.3.2 Equation Numbering

Each equation in the test document is to be sequentially numbered for identification and ordered in the proper sequence in which they are evaluated. Each term in the equation, whether a previously identified parameter, constant, or calculated quantity, may either be numbered or use a unique name in order to cross reference its origin.

In setting up a Rotor test the standard quantities listed on pages 2-8 of the "Rotor Data Reduction System" may be used as inputs to the non-standard computations and referenced by name.

The example included in this section (Figure A4) shows a series of equations, each assigned an item number and each also includes a variable name and a short description.

500	Engine Parameters (Cont.)		
ITEM			
507	TNC(X)	-	Core Engine Exit Rake Temperatures, XXXX.X°R, (X) = Measurement Numbers 592 - 603
508	TNCAV	-	Core Engine Nozzle Average Total Temperature, XXXX.X°R = $\frac{1}{12} \sum_{N=1}^{12} TNC(X)_N$,
509	DELTAT	-	Total Pressure Reference = $\frac{PBAR}{14.696}$
511	PTF(X)	-	PBAR Fan Inlet Total Pressures, PSIA Measurement Numbers 122 - 201

Figure A4. Cross Referencing of Terms in an Equation

Cross-referencing the instrumentation is illustrated in Figures A4, A5 and A6. In Figure A4, the measurement numbers for Items 507 and 511 are shown. Instrumentation for Item 507, TNC, is labeled in the circled portion of the instrumentation configuration form, Figure A5. The first part of the instrumentation for Item 511, PTF, is indicated in the circled portion of the scanivalve set-up form shown in Figure A6.

2.3.3 Addition of Equation

Additional equations may be inserted by adding a, b, c... to the item number. Figures A7 and A8 illustrate a before and after situation in which delta PTC and delta TIC were inserted as Numbers 567a and 569a.

2.3.4 Arithmetic Constants

Arithmetic constants, wherever used, should be clearly indicated as shown in the examples of this section. Often a summary list of all constants used in the equations is helpful for reference and should be included in the document. If it is anticipated that constants may be changed during a test, then that fact should be noted as such cases may need to be handled differently than normal in the program. In Figure A9, there is an indication that a table is to be used. Figures A9 and A10 are examples of tables.

2.3.5 Conversion Constants

Conversion constants, supplied by the instrumentation engineer, will be checked by the research engineer before they

LOW SPEED WIND TUNNEL INVESTIGATIONS BRANCH

INSTRUMENTATION CONFIGURATION

Project Title: ______________________ Page ____ of ____

Project Engineer: ______________ Facility: ______________ Rev. ____

Date ______

MN	Measurement	Transducer	Engineering Units	Magnitude	Positive Direction (EU)	Sig. Freq.	Monitoring Requirements	N/C
592	TC TNC	CA TC	°F	1500	INCREASING TEMP	0		N
593								
594								
595								
596								
597								
598								
599								
600								
601								
602								
603								
826	TC S.V. BOX	IC TC	°F	120	INCREASING TEMP	0		N
827	ROTOR FLAP	POTENTIOMETER	DEGREES	±9	TIP UP	100	OGR, CRO, BCM	C
828	VERTICAL ACC.	STATHAM A73TC-5-350	g	±4	MOTION UPWARD	100	BCM	N

5/82

Figure A-5.—Sample sheet instrumentation.

LOW SPEED WIND TUNNEL INVESTIGATION BRANCH

SCANIVALVE SETUP

Project Title ____________________ Date __________

SV Assembly (NO.) Module (NO.) Project Engineer __________ Revision —

Pressure Range 2.5 PSID Reference Pressure __________ Calib. Pressure __________

Transducer Mfgr. and Model — Serial —

Cycle No.	Part No.	Tube No.	Location	Description
1	48			
2	1			
3	2	PCAL		
4	3	122	NO. 1 INLET RAKE	PTF
5	4	123		
6	5	124		
7	6	125		
8	7	126		
9	8	127		
10	9	128		
11	10	129		
12	11	130		
13	12	131		
14	13	132	NO. 2 INLET RAKE	PTF
15	14	133		
16	15	134		
17	16	135		
18	17	136		
19	18	137		
20	19	138		
21	20	139		
22	21	140		
23	22	141		
24	23	142	NO. 3 INLET RAKE	PTF

Cycle No.	Part No.	Tube No.	Location	Description
25	24	143		
26	25	144		
27	26	145		
28	27	146		
29	28	147		
30	29	148		
31	30	149		
32	31	150		
33	32	151		
34	33	152	NO. 4 INLET RAKE	PTF
35	34	153		
36	35	154		
37	36	155		
38	37	156		
39	38	157		
40	39	158		
41	40	159		
42	41	160		
43	42	161		
44	43			
45	44			
46	45			
47	46			
48	47			

Figure A-6.–Sample sheet instrumentation.

500	Engine Parameters (Cont.)		
ITEM			
567	PTC(X)	-	Compressor Face Rake Total Pressure, psi Measurement Numbers 844 to 858
568	PSC(X)	-	Compressor Face Static Pressures, psia Measurement Numbers 859 to 861
569	TIC(X)	-	Compressor Face Rake Temperatures, °R Measurement Numbers 862 to 876
570	PBLL(X)	-	Inlet Boundary Layer Rake, Left Engine, psia Measurement Numbers 834 - 838

Figure A7. Parameters Before Additions

500	Engine Parameters (Cont.)		
ITEM			
567	PTC(X)	-	Compressor Face Rake Total Pressure, psi Measurement Numbers 844 to 858
567a	ΔPTC(X)	-	PTC/PBAR
568	PSC(X)	-	Compressor Face Static Pressures, psia Measurement Numbers 859 to 861
569	TIC(X)	-	Compressor Face Rake Temperatures, °R Measurement Numbers 862 to 876
569a	ΔTIC(X)	-	TIC(X) - TTO
570	PBLL(X)	-	Inlet Boundary Layer Rake, Left Engine, psia Measurement Numbers 834 to 838

Figure A8. Parameters After Additions

513 PTFAV - Fan Inlet Average Total Pressure, XX.XXX PSIA

$$= \frac{1}{SINL} \sum_{N=1}^{80} [PTF\ (X)_N]\ AI_N$$

Where PTF(X) From 511

AI_N = Area Weighing Factor

SINL = Area of Fan Inlet, 1416.6 in^2 at Rake Measuring Station.

N	AI (IN^2)	PTF(X)
1	See Table II	PTF (122)
2		PTF (123)
"		"
"		"
"		"
"		"
80		PTF (201)

Table II. Fan Inlet Area Weighing Values

N	PROBE NO.		AI in^2 (Each Probe)
1-8	PTF (122), (132), (142), (152), (162), (172), (182), (192)		16.8
73-80	PTF (131), (141), (151), (161), (171), (181), (191), (201)		25.88
	Remainder of Pressures		
9-16	PTF	123-130	16.8
17-24		133-140	16.8
25-32		143-150	16.8
33-40		153-160	16.8
41-48		163-170	16.8
49-56		173-180	16.8
57-64		183-190	16.8
65-72		193-200	16.8

Figure A9. Sample Use of Tables

TABLE V & TABLE VI FAN DUCT RAKE STATIC PRESSURE INTERPOLATION

N	PTFN(x)	RF(in)	PSNF(X1)	PSNF(X2)	RFS1	RFS2	AF
1	412	24.47	484	485	24.09	2.401	13.96
2	413	23.71					
3	414	22.92					
4	415	22.11					
5	416	21.27	485	486	21.69	2.864	
6	417	20.39					
7	418	19.47					
8	419	18.82					
9	420	24.47	487	488	24.09	2.401	14.45
10	421	23.71					
11	422	22.92					
12	423	22.11					
13	424	24.47	488	489	21.69	2.864	
14	425	23.71					
15	426	22.92					
16	427	22.11					
17	428	23.47	490	491	24.09	2.401	14.42
18	428	23.71					
19	430	22.92					
20	431	22.11					
21	432	21.27	491	492	21.69	2.864	
22	433	20.39					
23	434	19.47					
24	435	18.82					
25	436	23.87	493	494	23.51	2.269	15.86
26	437	23.15					
27	438	22.41					
28	439	21.64					
29	440	20.84	494	495	21.24	2.691	
30	441	20.02					
31	442	19.15					
32	443	18.55					
33	444	27.96	496	497	27.64	2.689	14.55
34	445	27.33					
35	446	26.67					
36	447	26.60					
37	448	25.31					
38	449	24.60	497	498	24.96	1.473	
39	450	23.86					
40	451	23.48					
41	452	23.87	499	500	23.15	2.269	16.14
42	453	23.15					
43	454	22.41					
44	455	21.64					
45	456	20.84	500	501	21.24	2.691	
46	457	20.02					
47	458	19.15					
48	459	18.55					
49	460	24.47	502	503	24.09	2.401	15.78
50	461	23.71					
51	462	22.92					
52	463	22.11					
53	464	21.27	503	504	21.69	2.864	
54	465	20.39					
55	466	19.47					
56	467	18.82					

Figure A10. Sample Table

are submitted to the programmer. Generally, these are not required until shortly before the test begins. However, they should be clearly indicated in the test document wherever used.

Figure A11 illustrates the use of the measurement number (indicated by a square) and the item number (circled) for least chance of misunderstanding.

2.3.6 Revisions to the Document

Minor revisions to the specifications can easily be implemented by insertions and additions as noted in the previous sections. Major revisions affecting large groups of parameters or equations may, in some cases, require the rewriting of one or several pages of the document. In this case, new pages should be written and the original page numbers should be appended with alphabetic characters to indicate page inserts, i.e. pages 24 and 24a, and have the date of revision and the revision number on the upper right corner.

In all cases, revised specifications must be dated and forwarded to the programmer.

The same policy applies to all changes in the instrumentation setup. Each revision of instrumentation information must be forwarded to the programmer without delay.

2.4 DATA PRESENTATION

Well specified output requirements and layouts provide the programmer with an exact proposal for the presentation of tabular or graphical program output. Print and plot layouts are followed precisely by programmers, and are assumed to be exact requirements of the engineer.

2.4.1 Printer Output

The desired output must be laid out indicating the range and decimal places to be printed. Standard forms are used for line printer data layouts and these forms are available from the programming group upon request. Figures A12 and A13 are two examples illustrating large and small amounts of data to be printed for each data point. The maximum number of spaces across the page is 131. The maximum number of lines down the page is adjustable. For the normal 8 1/2 inch sheet, there are 45 lines of print at 6 lines per inch, or 60 lines of print at 8 lines per inch. Normally, the 6 lines per inch density is used and will be assumed if not otherwise specified.

Output for a rotor test always includes standard items in a fixed format. The non-standard output will be appended to the standard output with the appropriate header lines added. The requestor should follow the above guidelines for the specification of non-standard output. Figure A14 is an example of typical rotor test output format.

Conversion Constants:	
FUEL FLOW (lt) #558	
85.1 ppm = 2.84 v = 9088 cts	.009364 ppm/ct
FUEL FLOW (rt) #559	
84.2 ppm = 2.80 v = 8960 cts	.009397 ppm/ct
PRESS FAN EXIT (inst. 883) #573	
.00413185 v/psia	.0003781 psia/ct
PRESS FAN EXIT (inst. 884) #574	.0009312 psia/ct
PRESS FAN EXIT (inst. 885) #575	.0009312 psia/ct
PRESS FAN EXIT (inst. 886) #576	.0009428 psia/ct
PRESS PS3 (lt.) (inst. 887) #711	.039269 psi/ct
PRESS PS3 (rt.) (inst. 888) #712	.040211 psi/ct
NGL, NGR #554, #555	1.0
PCAL1 #210	.00031 psi/ct
PCAL2 #211	.00031 psi/ct

Figure A11. Itemization of Conversion Constants

2.4.2 Graphics Output

Plotting requirements, defined in detail and plot layouts for each required plot, should be supplied. The following checklist of items specifies the typical considerations related to graphics software. Each point should be addressed, as required, in the software requirements provided by the researcher.

The attached examples indicate the typical manner in which plot layouts may be presented. Figure A15 is a layout of plots to be made on the Versatec plotter or CRT screen. Figure A16 would suffice for a graphics display of pressure data. In both cases, a narrative description discussing the items in the previous checklist should accompany the plots. The narrative should also include any additional information pertinent to the plots. The layouts serve as a guideline to the programmer specifying how the finished plot should appear.

2.4.3 Monitor Mode Program and Display

The monitor mode program should include only data which is required for test guidance and safety. Core space and CPU time are severely limited due to the real-time aspect. Standard items are calculated and displayed if requested. In addition, a special routine can be written to compute and display items that are test dependent or not generally displayed.

The screen has a limit of 2 columns with 16 lines in each. Test heading requires one line of both columns. Also, the run, sequence number, time and date require a line of both columns. These two items do not necessarily need to be at the top of the screen. Data will be displayed with a 1 to 4 character name and 4 significant digits in E format. Figure A17 can be used as a guide for monitor mode display screen setup. Make sure all equations and conversion constants have been supplied.

2.4.4 Dynamic Data Reduction for Rotor Tests

The Dynamic Data programs are described in the manual entitled "Rotor Data Reduction Systems". To utilize these programs the "High Speed Pre-Test Information" and "High Speed Data Reduction Input" forms must be completed by the project and instrumentation engineers (see Figures A18 and A19).

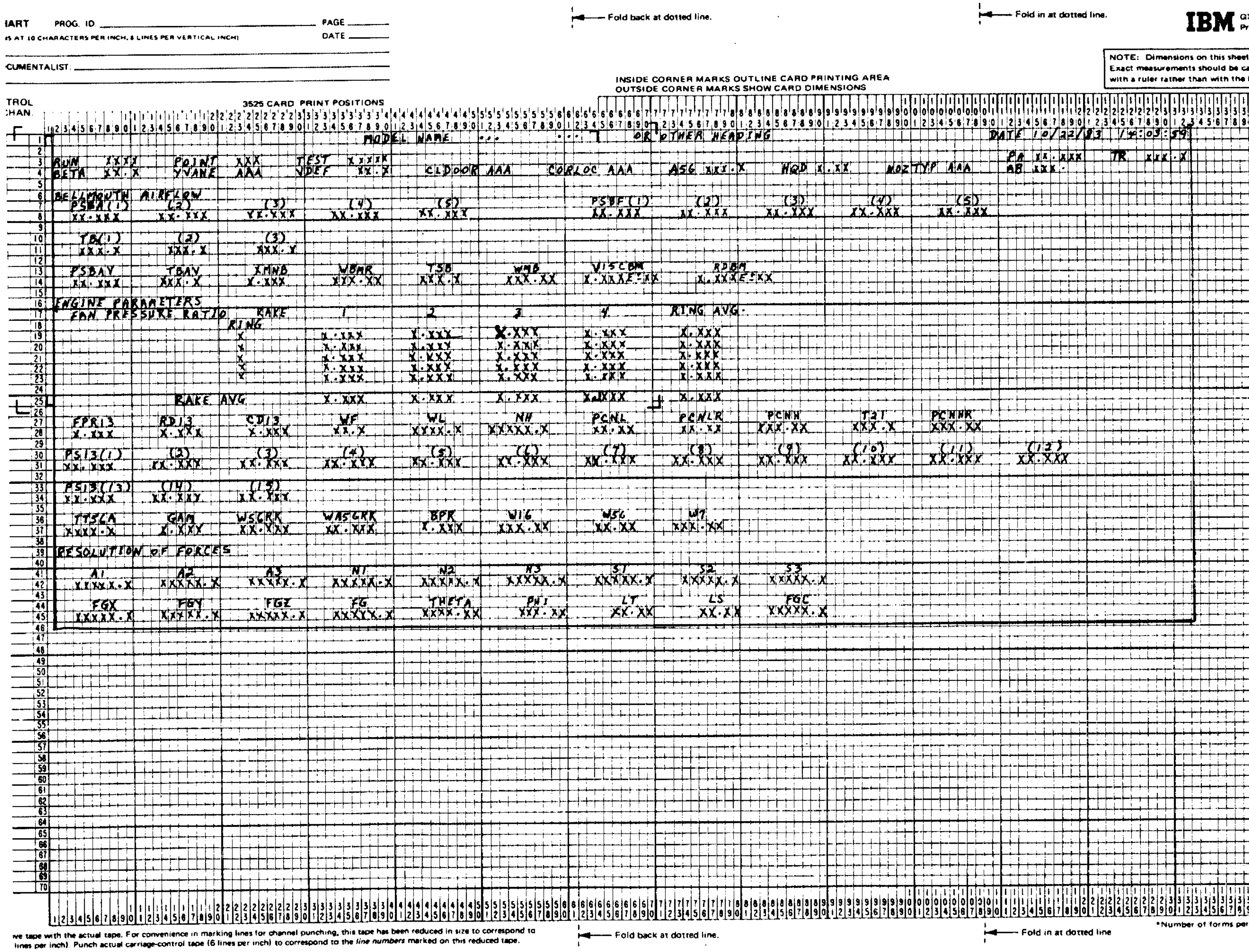


Figure A-12.—Sample line printer layout.

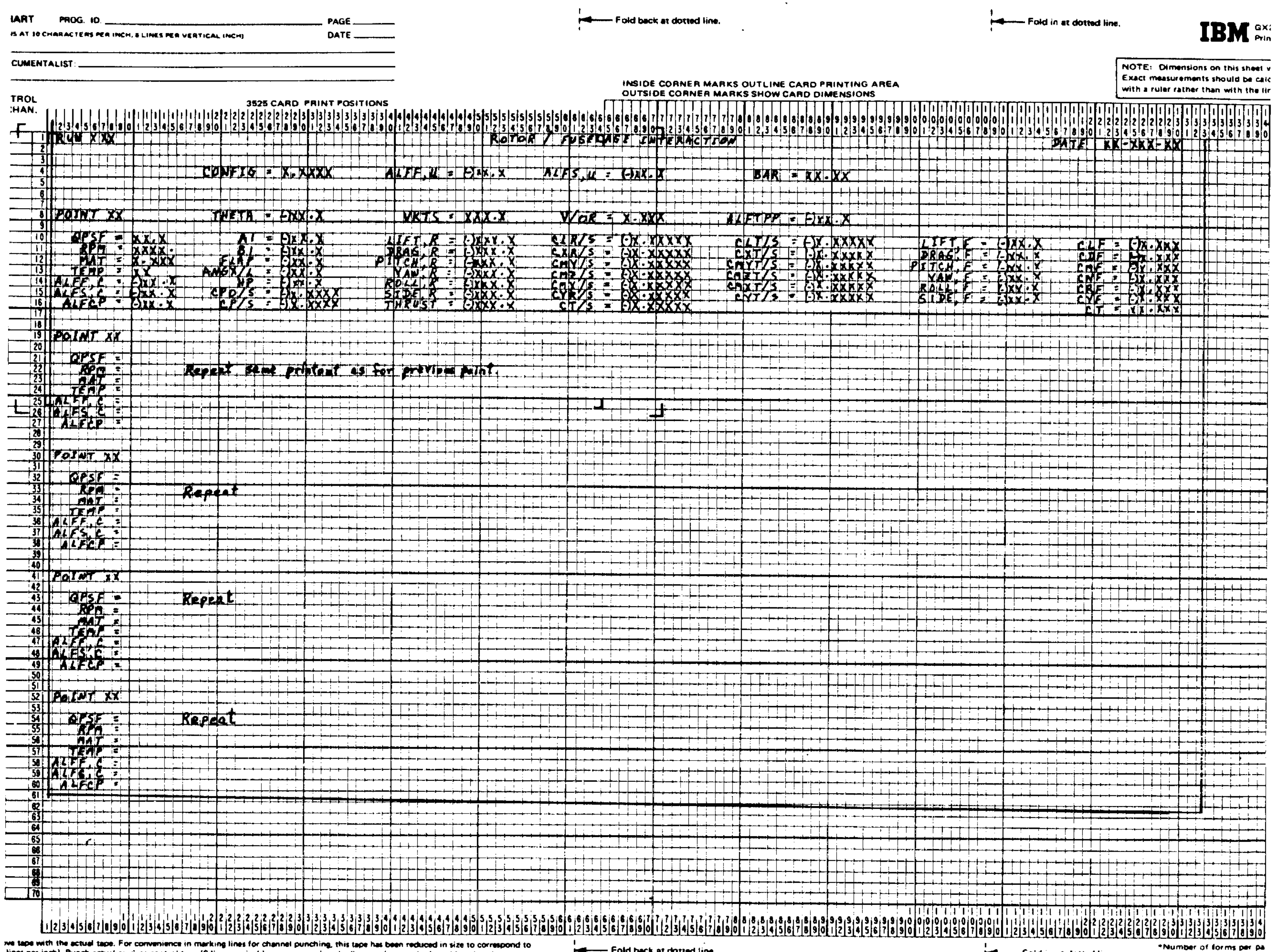


Figure A-13.—Sample line printer layout.

```
TEST  550   RUN  13                              BOEING BMR                            COMPUTED ON 02/21/80 AT 17:26:51

ROTOR TERMS           WING TERMS      BALANCE & MOMENT CENTERS       DELTA Q           STATIC  2                  WALL EFFECTS

AREA    =    57.10   AREA =    57.10   H = 26.1970  X =  -3.083  -.1635E-01 CONST     S1 = -106998.           CAT =      0.0000
RADIUS =   16.11     CBAR =    1.000   J = -0.0260  Y =   7.1600  0.1668E-01 QU        S8 = -49098.            CMT =      0.0000
SIGMA  = 0.07000     SPAN =    1.000   K = 16.0     DX =   0.000  0.44895E-03 QU**2    S3 =         0.
FEE    = 0.00000                                    DY =   0.000  -.2208E-05 QU**3     S4 =         0.
                                                                   0.6408E-08 QU**4

                 -------------- Q LESS THAN  25. ------------                           -------------- Q GREATER THAN  25. --------------
AERO TARES    L/Q TR    D/Q TR    M/Q TR     Y/Q TR    N/Q TR    ROLL/Q TR       L/Q TR    D/Q TR     M/Q TR    Y/Q TR    N/Q TR  ROLL/Q TR

0. CONSTANT 17.93454 17.95778 -34.24504  -1.60367  33.12758  10.93792  0. 12.80000 15.93418 -38.00000  -0.63000   9.52626   2.04156
1.  ALPHA    1.31330  0.21105   3.16983   0.05818   0.02455   0.03299  1.  1.81000  0.22535   6.87000   0.07000   0.92656   0.68778
2. ALPHA**2 -0.03982  0.02131  -0.77196   0.00230   0.00457  -0.03459  2.  0.00000  0.02685   0.00000   0.00000   0.07026   0.04564
3. ALPHA**3  0.00220 -0.00043   0.00577  -0.00005   0.00089   0.00792  3.  0.00000 -0.00024   0.00000   0.00000  -0.01174  -0.00023
6. Q         0.00000  0.00000   0.00000   0.00000   0.00000   0.00000  6.  0.00000  0.00000   0.00000   0.00000   0.00000   0.00000
7. Q**2      0.00000  0.00000   0.00000   0.00000   0.00000   0.00000  7.  0.00000  0.00000   0.00000   0.00000   0.00000   0.00000
8. PSI       0.00000  0.00000   0.00000   0.00000   0.00000   0.00000  8.  0.00000  0.00000   0.00000   0.00000   0.00000   0.00000
9. PSI**2    0.00000  0.00000   0.00000   0.00000   0.00000   0.00000  9.  0.00000  0.00000   0.00000   0.00000   0.00000   0.00000

SPECIAL INSTRUMENT CONVERSION CONSTANTS
POW =  -1.00000  DANG=    0.00100  BAR =    0.00100  RPM =    1.00000  ACT1=    0.00010  ACT2=    0.00010  ACT3=    0.00010
OFFSET     0.00          0.00               0.00              0.00             0.00             0.00             0.00

                                                      ZERO POINT READINGS

---------------------------- SCALE DATA ---------------------------------                ----- SPECIAL INSTRUMENT DATA -----
 CR        RL-       RL+       Q          D         CF        FL+       FL-               POW      DANG      BAR       RPM
 9189      3511      9176           0   15203       9196      6174      3371                79        -4     29650       234

                                                                                          ACT1     ACT2      ACT3
                                                                                          -6849     4225      3975

                       FACTOR TABLE DATA

   0.00   62.00   0.00   0.00
```

Figure 14.—Sample of a rotor test computer printout.

Plotting Requirements Checklist:

1. Axis set-up (for both X and Y axis).

   a. Scales (minimum, maximum, and increment values).
   b. Gridding desired? Grid should be related to increment size.

2. Labeling

   a. For axis: labels, number of maximum characters.
   b. Plot titling; how many lines

3. Plot Data

   a. Marking data points - usually one of the following methods is used:

      (1) Each data point marked with a symbol.
      (2) Each data point marked with a symbol and all symbols connected by lines.
      (3) Symbols not used; data points connected by straight lines.

   b. If symbols used, then specify symbol (i.e., o, x, *, etc.).

4. Line drawing considerations include:

   a. Linear interpolation.
   b. Curve fits of data (spline, least squared, etc.).
   c. Type of lines used (solid, dotted, dash, etc.) to draw curves.

5. Plot legends - layout if needed.

6. Other options.

   a. Multiple plots per page or display - define number.
   b. Define input data, equations, etc. needed for generating plot data.
   c. Multiple runs per plot.
   d. Constraints

7. Drawings depicting all the above will help in the organization.

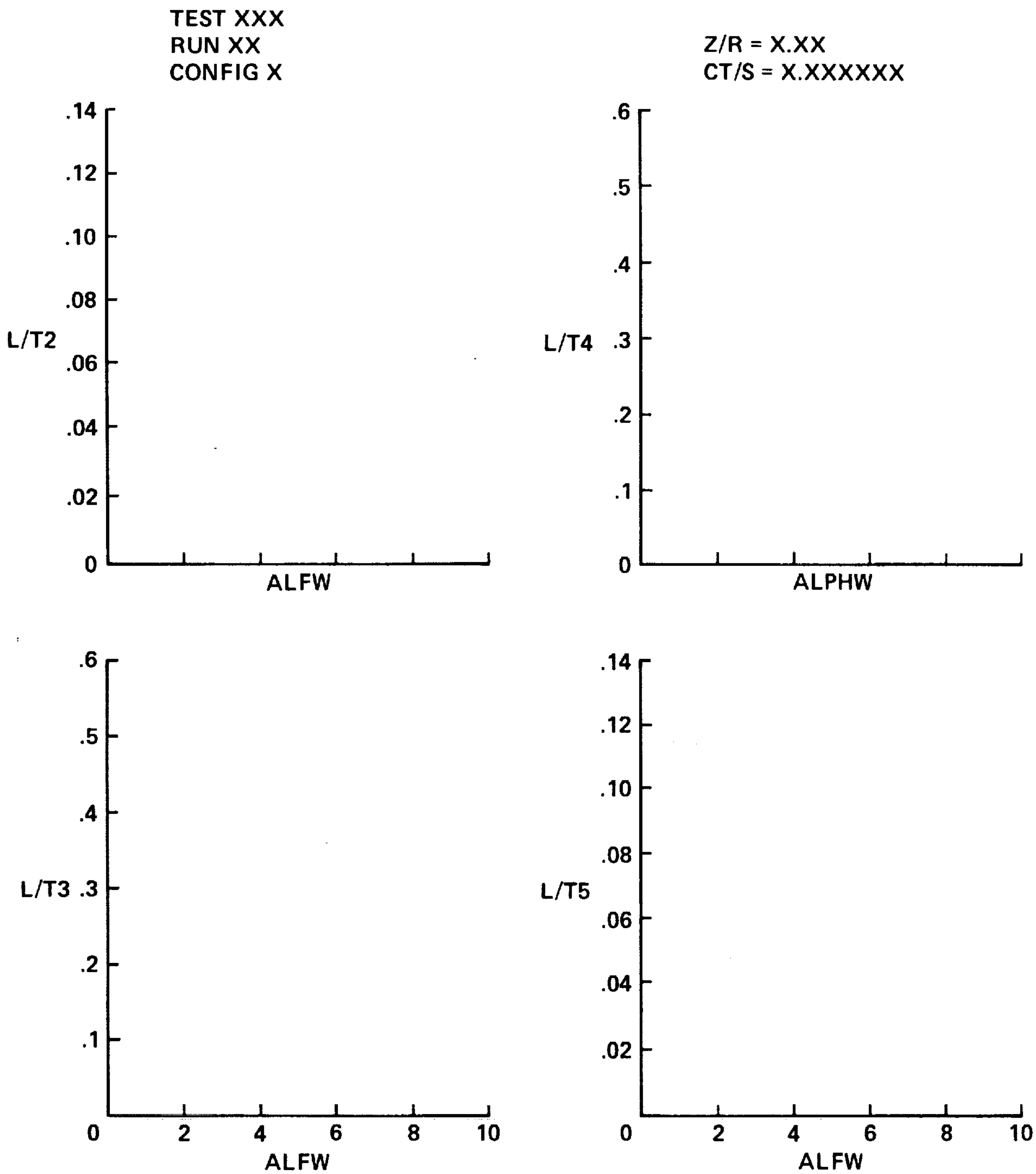


Figure A-15.—Example of a typical layout of plots for Versatec plotter or CRT screen.

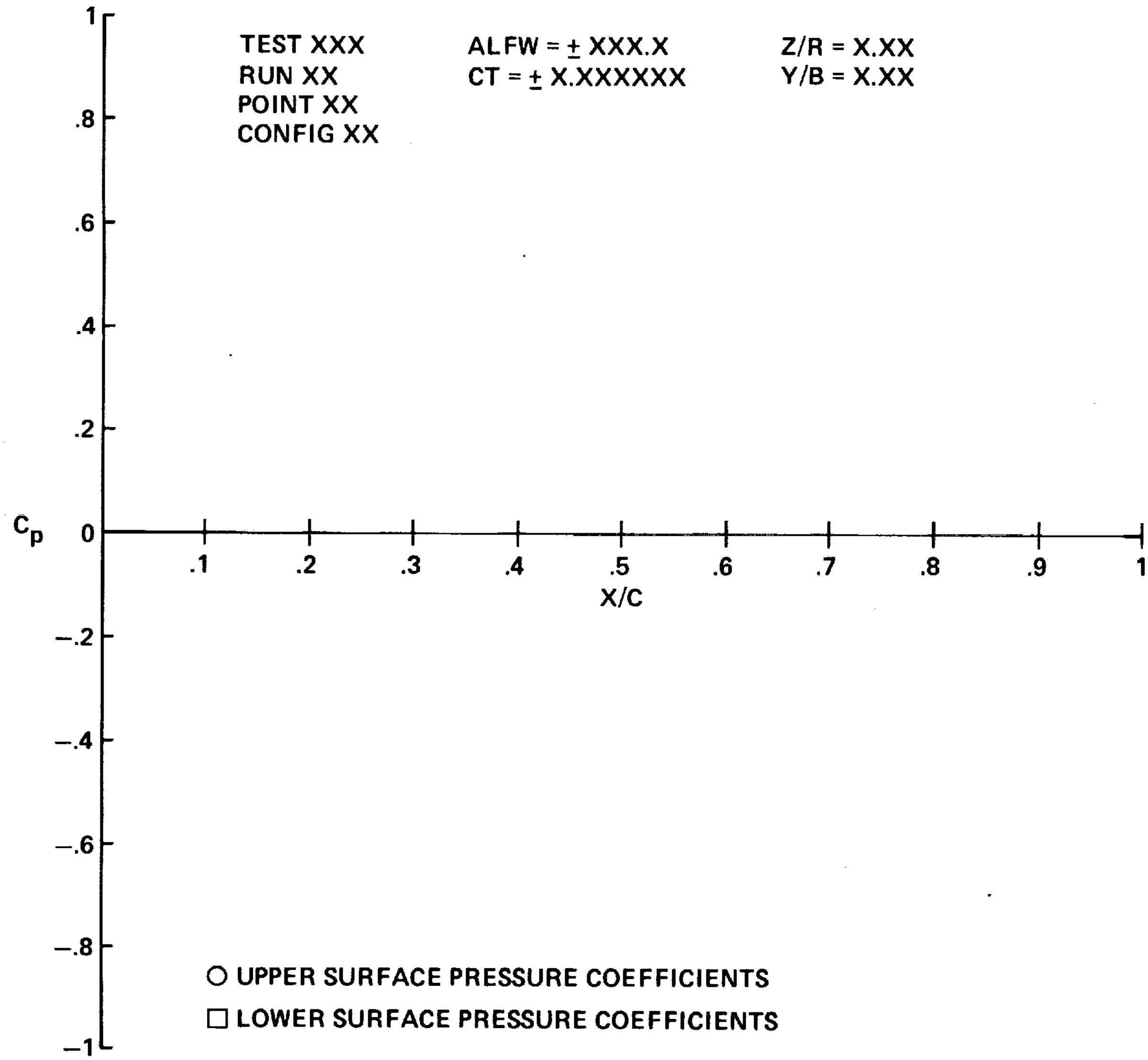


Figure A-16.—Typical graphics display of pressure data.

R	U	N		X	X	X		S	E	Q		X	X	X		D	D	-	M	M	-	H	H	:	M	M	:	S	S

Figure A17. Display Screen Setup Sheet

HIGH SPEED PRE-TEST INFORMATION

PARAM NAME	DEFINITION	VALUE
ID	12 character test name	
NTEST	Test number	
NC	No. of active channels on test	
NRV	No. of revolutions of data to be analyzed (should be a power of 2 for efficient harmonic analysis.) 0 < NRV > = 8 Usually NRV = 8	
NSK	No. of revolutions of data to be skipped before analysis begins (program always skips 1 rev) Usually NSK = 3	
NHR	No. of integer harmonics to be computed Usually NHR = 10	
NPLS	No. of integer harmonics to be stored for subsequent printing and plotting NPLS < NHR Usually NPLS = NHR	
NPLT	No. of revolutions of original high speed data to be stored for printing and plotting (NPLT < NRV) - this value does <u>not</u> include the smoothed revolution of data Usually NPLT = 3	
NR1	First scan of RCAL data to be read (Usually 10)	
NR2	Last scan of RCAL data to be read (Usually 20)	
NC1	First scan of zero data to be read (Usually 50)	
NC2	Last scan of zero data to be read (Usually 150)	
NSC	No. of scans per revolution	

Figure A18. High Speed Pre-Test Information

Date: ______________

Page No.: __________

HIGH SPEED DATA REDUCTION INPUT

CHANNEL NUMBER	INPUT RCAL STEP	RCAL EQUI-VALENCE	OFFSET	CHANNEL NAME TO APPEAR ON OUTPUT 16 CHARACTERS MAXIMUM	UNITS	POSITIVE DIRECTION	OPRCAL	CHFIL

Figure A19. High Speed Data Reduction Form

2.5 PROGRAM CHECKOUT AND TEST CASES

Adequate lead time for software development includes the time required for program checkout accomplished prior to production use of the software. The notion of test cases encompasses two categories of software checkout procedures.

Normally, programmer test cases are contrived exercises designed to check the software at the module or program level. These tests are designed to specifically verify such items as data flow and logic, print output formatting, graphics output formatting, computational algorithms and use of input/parameter files and internal flags.

The second class of test case, is that in which a researcher desires a fully checked program, including the complete spectrum of processing from input to computations to output. In this situation, the accuracy of the program as well as its logical data flow is under examination. This type of test case is highly recommended. The following considerations apply:

1. Meaningful data must be defined for all channels of all data types and each port of each scanivalve unit that are to be checked. Ideally, this data should be in counts. However, where this is very difficult to compute, engineering units may be used.

2. Computational parameters, table lookups, and conversion constants must all be supplied.

3. Provisions must be made for time and staff required to perform hand checks of results.

3. INSTRUMENTATION

3.1 Instrumentation Lead Time

Instrumentation requirements must be provided to the Instrumentation Group Leader no later than six months prior to the scheduled test date. In some cases, this will be earlier than the software requirements are needed. This is necessitated by the need to schedule the utilization of the finite instrumentation equipment resources available. Delays in submittal may result in test slippage because of long lead time items or instruments calibrated not being available.

3.2 Instrumentation Requirements Submittal

The complete instrumentation requirements documents are to be submitted to the FHW Instrumentation Group Leader, who will review the requirements and assign the project to an instrumentation engineer. The instrumentation engineer will initially establish man loading, hardware assignments, calibration requirements and long lead time procurement. He/She will meet with the research engineer and programmer to coordinate the pre-test preparation.

3.3 Instrumentation Documents

To assist the research engineer and instrumentation personnel, four forms have been developed to provide a consistent format for organization and presentation of instrumentation requirements. The instrumentation document will consist of these forms plus the basic project background information as described in the software section. The document should also include sketches and drawings of instrument and measurement station locations. The four instrumentation forms are:

1. Instrumentation Configuration Form
2. Instrumentation Calibration Form
3. Scanivalve Setup Form
4. Scanner Setup Form

The Instrumentation Configuration Form will define the types and quantities of measurements required for the test. The Instrumentation Calibration Form will provide the information required for the setup of the instrumentation devices specified on the configuration form. The last two forms will provide information on the hookup of pressures and other instrumentation to be scanned, such as temperatures. The following four sections are specific instructions on how the forms are to be completed.

3.3.1 <u>Instructions for Instrumentation Configuration Form (Figure A20)</u>

Measurement Number (MN): Assign a unique MN for each specific parameter. This number will be used throughout the project to coordinate the programming and instrumentation so that definition of terms will not lead to misunderstandings. If a measurement is deleted from the project, its MN will not be reused for another, added measurement.

Measurement: Assign a unique name for each measurement. It shall be used consistently throughout the project and shall not be reused for an added measurement if the original measurement is deleted.

Transducer: Enter the transducer name and model number. If a model number is not known, enter the type and full scale range required. Transducer selection must be made at an early date in a test program to allow for a long lead time in obtaining the hardware.

Engineering Units (EU): Enter the engineering units (i.e., psia, pounds) in which the measurement is to be displayed or calculated.

Magnitude: Enter the maximum expected value (both positive and negative) of the measurement.

Positive Direction: Define the physical direction of movement, strain, pressure, etc. of the measurement which results in a <u>positive voltage</u> in the data system.

Signal Frequency: Defines the maximum frequency of interest (in Hertz) contained in the measurement signal.

Monitoring Requirements: List the requirements for monitoring the measurement via real time hardware (i.e., oscillograph, oscilloscope, digital panel meters, bar chart display, etc.)

are defined in the column. The following acronyms are to be used:

CRO	Control Console Oscilloscope
OSC	General Purpose Oscilloscope
OGR	Oscillograph
BCM	Bar Chart Monitor
DPM	Digital Panel Meter
CCTR	Computing Counter

N/C: Identify whether the NASA personnel or contractor are responsible for the information.

3.3.2 Instructions for Instrumentation Calibration Form (Figure A21)

Measurement Number (MN): Assign a unique MN for each specific parameter. This number is to be used throughout the project to coordinate the programming and instrumentation so that definition of terms will not lead to misunderstandings. If a measurement is deleted from the project, its MN will not be reused for another, added measurement.

Measurement: Assign a unique name for each measurement. It shall be used consistently throughout the project and will not be reused for an added measurement if the original measurement is deleted.

Engineering Units (EU): Enter the engineering units (i.e., psia, pounds) in which the measurement is to be displayed or calculated.

LOW SPEED WIND TUNNEL INVESTIGATIONS BRANCH

INSTRUMENTATION CONFIGURATION

Project Title: ______________________ Page ____ of ____

Project Engineer: ______________ Facility: ______________ Rev. ______

Date ______

MN	Measurement	Transducer	Engineering Units	Magnitude	Positive Direction (EU)	Sig. Freq.	Monitoring Requirements	N/C

5/82

Figure A20. Instrumentation Configuration Form

Tare: Enter the value of the measurement, in engineering units, when the model is in the reference position used to acquire a zero point.

Monitor Calib: Enter the desired EU/division for each instrument used to monitor the measurement in real time for test conductance.

Monitor Redlines: Enter the alarm value in engineering units for each instrument used to monitor the measurement in real time for test conductance.

* Ex. Volt: Enter the excitation voltage in volts requested for each transducer.

* Rcal (KΩ): Enter the resistor value in KΩ requested for each measurement to be used to provide an Rcal equivalent for each measurement.

* Rcal Equiv (EU): Enter the EU change equivalent to the insertion of the above Rcal across one leg of a bridge. If an Rcal is not to be used, enter the EU pev volt sensitivity of the transducer.

* Rcal (mv): Enter the offset in mv caused by placing the above Rcal across one leg of a bridge.

* Dig: Is a wiring diagram provided which is complete? (Y OR N).

N/C: Identify whether the NASA personnel (N) or contractor (C) are responsible for the information.

* Information supplied by contractors for transducers supplied by contractor, otherwise information supplied by NASA.

LOW SPEED WIND TUNNEL INVESTIGATIONS BRANCH

INSTRUMENTATION CALIBRATION

Project Title: ______________________ Page ____ of ____

Project Engineer: ______________ Facility: ______________ Rev. ________

Date ________

MN	Measurement	Engineering Units	Tare (EU)	Monitor Calib. (EU/Div)	Monitor Redlines (EU)	Ex. Volt	RCal (K)	RCal Equiv(EU)	RCal (mv)	Dig	N/C

5/82

Figure A21. Instrumentation Calibration Form

3.3.3 Instructions for Scanivalve Setup Form (Figure A22)

SV Assembly: Assign a consecutive number for each assembly beginning with 1. Normally, no more than 4 assemblies are allowed per test.

Module: Assign the module number in the above assembly. A maximum of six modules can be assembled on one stepper motor. The numbers begin with one next to the stepper.

Pressure Range: Enter the full scale range of the pressure transducer required for the above module.

Reference Pressure: Define the pressure which is to be applied to the reference side of the transducer. If the transducer is not differential, then this is not applicable (N/A).

Calib. Pressure: Enter the pressure to be applied to the calibration port. The source for this pressure is located in the control room and has two pressure controllers. One is 0 to +10 psig or 0 to -10 psig and the other is 0 to +35 psig except in the 7- by 10- where the second source is 0 to +10 psig.

Transducer Mfgr. and Model: Enter this data if known.

Serial: Enter the transducer serial number if known. This will normally be entered by NASA technicians after the SV assembly is complete.

Tube No: Enter an identifying number unique to each orifice. These numbers should be consecutive for each test to prevent confusion when the SV assemblies are installed and leak checked in the test article.

Location: Devise systematic location scheme is to be devised and the location of each orifice is entered in this column (i.e., span and chord ordinates).

Description: Enter the measurement and MN, plus any other pertinent information.

3.3.4 Instructions for Instrumentation Scanner Setup (Figure A23)

Scanner No: Assign consecutive numbers to each scanner in a particular test.

Calib. Voltage: Determine a reference voltage from 0 to ±10 to be located on each scanner.

Location: A systematic location scheme is to be devised and the location of each measurement is entered in this column (i.e., span and chord ordinates).

Description: Enter the measurement, MN, and any other pertinent information.

3.4 Revisions of Instrumentation

In the normal process of test preparation, the instrumentation requirements are modified for numerous reasons including model fabrication restrictions, changes in research objectives and availability of equipment. As instrumentation requirements are changed, it is the responsibility of the research project engineer to submit revised forms to both the software programmer and instrumentation engineer. The instrumentation engineer will assign a revision number to the change and maintain a revision summary on the form presented in Figure A24.

LOW SPEED WIND TUNNEL INVESTIGATION BRANCH

SCANIVALVE SETUP

Project Title ______________________________ Date ____________

SV Assembly ________ Module ________ Project Engineer ________ Revision ________

Pressure Range __________ Reference Pressure __________ Calib. Pressure __________

Transducer Mfgr. and Model ______________________________ Serial ____________

Cycle No.	Part No.	Tube No.	Location	Description	Cycle No.	Part No.	Tube No.	Location	Description
1	48				25	24			
2	1				26	25			
3	2				27	26			
4	3				28	27			
5	4				29	28			
6	5				30	29			
7	6				31	30			
8	7				32	31			
9	8				33	32			
10	9				34	33			
11	10				35	34			
12	11				36	35			
13	12				37	36			
14	13				38	37			
15	14				39	38			
16	15				40	39			
17	16				41	40			
18	17				42	41			
19	18				43	42			
20	19				44	43			
21	20				45	44			
22	21				46	45			
23	22				47	46			
24	23				48	47			

Figure A22. Scanivalve Setup Form

LOW SPEED WIND TUNNEL INVESTIGATIONS BRANCH

SCANNER SETUP

Project Title ______________________ Date __________

Scanner No. ________ Calib. Voltage ________ Project Engineer ________ Revision ________

Cycle No.	Input No.	Location	Description
1	H		
2	1		
3	2		
4	3		
5	4		
6	5		
7	6		
8	7		
9	8		
10	9		
11	10		
12	11		
13	12		
14	13		
15	14		
16	15		
17	16		
18	17		
19	18		
20	19		
21	20		
22	21		
23	22		
24	23		

Cycle No.	Input No.	Location	Description
25	24		
26	25		
27	26		
28	27		
29	28		
30	29		
31	30		
32	31		
33	32		
34	33		
35	34		
36	35		
37	36		
38	37		
39	38		
40	39		
41	40		
42	41		
43	42		
44	43		
45	44		
46	45		
47	46		
48	47		

Figure A23. Instrument Scanner Setup Form

LOW SPEED WIND TUNNEL INVESTIGATIONS BRANCH

INSTRUMENTATION REVISIONS

NUMBER	DATE	AFFECTED FORM	AFFECTED PARAMETERS IDs

Figure A24. Instrumentation Revision Form 5/82

APPENDIX B

Low Speed Wind Tunnel Investigations Branch

Test Readiness Review Forms

February 1984

FHW TEST READINESS REPORT

TEST NAME: ______________________ TEST NO: __________

FACILITY: ______________________ J.O. NO: __________

1. PRE-INSTALLATION ITEMS[3]

A. Test Boundaries and Structural Loads

Initial and Date When Completed

a. Model Support System Loads

Item	NASA	CONTRACTOR	SPONSOR
1. Maximum combined forces and moments estimated.			
2. Resulting forces within struts limits.			
3. Resulting loads within balance system limits.			

b. Critical Model Structural Elements

Item	NASA	CONTRACTOR	SPONSOR
1. All critical elements identified for detailed analysis.			
2. Stress calculations reviewed by FHW Facilities Tech. Group[4].			
3. Steady-state stresses are less than 1/5 of ultimate, or 1/3 of yield strength in critical elements.			
4. Dynamic load fatigue limits established, and justification for the limits is attached.			

c. Test Limits and Test Envelope

Item	NASA	CONTRACTOR	SPONSOR
1. Dynamic stability boundary calculations approved.			
2. Requirements and limits on angle of attack and yaw established.			
3. Additional test limits identified (list attached).			
4. Test envelope established, based on above calculations and limits (envelope attached).			

NOTE:
1. Exceptions must be accompanied by written justification.
2. Designate non-applicable items as N.A. and initial.
3. See Planning Guide for facility being used.
4. To be initialed by FHW reviewer.

FHW TEST READINESS REPORT

TEST NO: ____________________

TEST NAME: ______________________________

FACILITY: ______________________________

Initial and Date When Completed

Item	NASA	CONTRACTOR	SPONSOR
B. Model Handling			
1. Model weight and c.g. calculated (or measured) and given to Mechanical Operations Group Leader.			
2. Hoisting sling loads calculated and hoisting clearances checked.			
3. Certified hoisting sling available.			
4. Model weight (______ lbs.) within crane capacity.			
5. Model installation form submitted to Mechanical Operations Group Leader.			
C. Flammable Fluids & Toxic Materials Precautions			
1. Vapor detection system installed.			
2. Fire extinguishing systems installed.			
3. Over-temp. system installed.			
4. Fuel supply system contamination checked.			
5. Fuel supply pumps and control valves checked.			
6. Onboard fuel tanks purged and filled with dry nitrogen.			
7. Hydraulic system contamination checked.			
8. Hydraulic system pumps and control valves checked.			
9. Toxic materials identified and safety provisions made (list attached).			
D. Instrumentation for Safe Operation			
1. Mandatory instrumentation identified and available (list attached).			
2. Operational limits established on all mandatory instrumentation.			

FHW TEST READINESS REPORT

TEST NO: ____________

TEST NAME: ____________

FACILITY: ____________

Item	Initial and Date When Completed: NASA	CONTRACTOR	SPONSOR
E. Control Systems and Procedures 1. Vital controls identified and fail safe. 2. Procedures written and agreed upon: Start, Stop, 3. Operation, Emergency. 4. Data/run forms written.			
F. Fragmentation Energy Levels Within Tunnel Armor Limits (If not within limits, state precautions that will be taken.)			
G. All High Pressure Air Systems Tested and Certified for Operation			
H. Systems Safety Analysis Completed and Approved			
I. Test Objectives and Test Schedule Approved			
J. Data Reduction Programming Complete and Operable			
K. Service Request Submitted For Model Photographs			
L. Approvals for Tunnel Installation			

	APPROVED
NASA Project Engineer	
Chief, FHA Branch	
Assistant Chief, FHW Branch	
Chief, FHW Branch	

TEST NO: ____________________

TEST NAME: ______________________________

FACILITY: ______________________________

II. PRE-TEST ITEMS

Initial and Date When Completed

Item	NASA	CONTRACTOR	SPONSOR
A. Flammable Fluids Precautions			
1. Over-temperature warning systems tested.			
2. Vapor detection systems tested.			
B. Instrumentation for Safe Operation			
1. Monitoring procedures agreed upon, personnel trained, and procedures prominently posted.			
2. Monitoring instrumentation calibrated.			
3. Measurement level limits posted.			
C. Operating & Emergency Procedures			
1. Test crew organized, trained, and briefed.			
2. Test crew briefed in emergency procedures.			
3. Wind Tunnel Emergency Stop Mode: Normal____; Critical____. (Include justification for critical mode.)			
D. Preparation Checklists Complete			
1. Instrumentation Preparation Checklist.			
2. Shift Leader's Test Section Preparation Checklist.			
3. Aircraft Mechanics Preparation Checklist.			
E. Community Noise Monitoring			
1. Noise monitoring equipment operational and calibrated.			
2. Community noise restrictions reviewed and integrated into test operation schedule.			

FHW TEST READINESS REPORT

TEST NO: ________________

TEST NAME: ______________________________________

FACILITY: ______________________________________

F. <u>Approvals for Tunnel Testing</u>	Initial and Date
NASA Project Engineer	APPROVED
Contractor's Project Engineer (If Applicable)	
Sponsoring Agency Project Engineer (If Applicable)	
Chief, FHA Branch	
Assistant Chief, FHW Branch	
Chief, FHW Branch	